

### III. Undertaking of the Republic of the Philippines

In accordance with the Notes Verbales exchanged between the Government of Japan and the Government of the Republic of the Philippines, the Government of the Republic of the Philippines shall accord privileges, immunities and other benefits to the Study team and, through the authorities concerned, take necessary measures to facilitate smooth conduct of the Study.

1. The Government of the Republic of the Philippines shall be responsible for dealing with claims which may be brought by the third parties against the members of the Study team and shall hold them harmless in respect of claims or liabilities arising in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims or liabilities arise from the gross negligence or willful misconduct of the above mentioned members.
2. NIST shall, at its own expense, provide the Study team with the following, in cooperation with other agencies concerned, if necessary.
  - (1) available data and information related to the Study
  - (2) counterpart personnel and laborers
  - (3) suitable office and technical study space with necessary equipment in NIST central office
  - (4) credentials or identification cards to the members of the Study team
  - (5) appropriate number of vehicles with drivers
  - (6) provision and delivery to NIST central office of raw materials
  - (7) clearing, handling and storage at the port/airport and inland transportation (to and from Project site) and custody of equipment, machinery and other materials to be brought into and then brought back to Japan by the Study team

3. NIST shall make necessary arrangements with other governmental and non-governmental organizations concerned for the following.

- (1) to secure the safety of the Study team
- (2) to exempt the members of the Study team from taxes, duties, fees and other charges on equipment, machinery and other materials brought into the Philippines for the conduct of the Study
- (3) to exempt the members of the Study team from income tax and charges of any kind imposed on or in connection with the allowances remitted from abroad
- (4) to secure permission for entry into private properties or restricted area for the conduct of the Study
- (5) to secure permission to take all data and documents related to the Study including photographs out of Philippines to Japan by the Study team
- (6) to provide medical facilities as needed, the expenses to be chargeable against the members of the Study team

#### IV. Undertaking of the Government of Japan

In accordance with the Notes Verbales exchanged between the Government of Japan and the Government of the Republic of the Philippines, the Government of Japan, through JICA, will take necessary measures for the implementation of the Study.

1. to dispatch, at its own expense, the Study team to the Republic of the Philippines
2. to pursue technology transfer to the Philippines counterpart personnel in the course of the Study

Scope of Works  
for the Study on  
The Establishment of the Powdered Activated Carbon Plants

I. Objective of the Study

The objective of the study is to evaluate the market, technical, economic and financial feasibility of the establishment of the Powdered Activated Carbon Plants in the Republic of the Philippines using tropical woods and wood wastes (hereinafter referred to as 'the Project').

II. Scope of the Study

In order to achieve the above objective, the Study will cover the following items:

1. Review and analysis of the background of the Project.

- 1.1 present situation and policy of industrial development in the Philippines
- 1.2 present situation and policy of activated carbon (powdered/granulated) industry in the Philippines
- 1.3 present situation and policy of the forestry and timber industry in the Philippines

2. Market Study

- 2.1 present situation and trend in the supply of activated carbon (powdered/granulated) in the Philippines
  - (1) supply from existing plants
  - (2) importation (volume, type of products and their sources)
- 2.2 present situation and trend in the consumption of powdered activated carbon in the Philippines, i.e. type of products, geographical distribution, sectoral consumption pattern and their volumes
- 2.3 distribution channels
- 2.4 forecast of demand of powdered activated carbon
  - (1) prospect of future demand for powdered activated carbon in the Philippines
  - (2) possibility of powdered activated carbon exportation

### 3. Study on the Raw Materials

#### 3.1. general survey of forest

- (1) general out-look of forest
- (2) quantity of resources
- (3) potential species (mainly on: (i) ipil-ipil  
(ii) coir dust (iii) kakauate (iv) apitong (v) falkata)

#### 3.2 Technical study and analysis on quality and suitability of the selected woods and wood wastes

- (1) wood crushing
- (2) thermogravimetric
- (3) carbonization
- (4) activation under various condition
- (5) chemical analysis
- (6) refining process
- (7) continuous activation
- (8) evaluation of powdered activated carbon

#### 3.3 selection of raw materials

#### 3.4 auxiliary raw materials

### 4. Study on the Plant Site

#### 4.1 reconnaissance of possible sites

#### 4.2 selection of priority site(s)

#### 4.3 detail study on the priority site(s)

- (1) availability of raw materials
- (2) natural conditions of the site(s)
  - (i) meteorology
  - (ii) geology and topography
- (3) socio-economic conditions
  - (i) population, labor force and wages etc.
  - (ii) industries
  - (iii) regional administration
- (4) utilities and infrastructure such as electricity, water, transportation (road, port and railway) and communication

Note: 3.1 and 4.1 mentioned above will cover a maximum of six (6) sites.

### 5. The Conceptual Design of the Plant

#### 5.1 study on the powdered activated carbon to be produced by the plant and their optimum production scale

#### 5.2 determination of the process

- 5.3 design standards and process flow sheet including material balance of the proposed plant
- 5.4 layout of the proposed plant
- 5.5 drawings of the plant
- 5.6 plant construction plan
  - (1) transport plan of materials
  - (2) implementation program
  - (3) organization and manpower plan
- 5.7 operation program including organization and manpower plan
- 5.8 environmental impacts analysis
6. Financial Analysis
  - 6.1 overall investment costs
  - 6.2 production cost
  - 6.3 projected balance sheet
  - 6.4 projected income statement
  - 6.5 projected cash flow statement
  - 6.6 financial internal rate of return
  - 6.7 sensitivity analysis
7. Economic and Social Evaluation
8. Conclusions and recommendations

### III. Framework and Schedule of the Study

The Study will be carried out in the following four steps:

1. Step 1 : preparation work both in Japan and in the Philippines
2. Step 2 : field of work in the Philippines
  - (1) market, raw materials and site survey
  - (2) technical study
3. Step 3 : home office work in Japan
4. Step 4 : presentation of and discussion on the Draft Final Report in the Philippines and presentation of Final Report

The tentative schedule of the Study is as shown in the attached sheet

This schedule, however, is subject to change according to circumstances

#### IV. Report

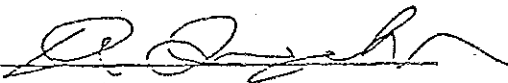
JICA will prepare and present the following reports to the Government of the Philippines

1. Inception Report written in English, at the start of the Step 2 in the III  
: 10 copies
2. Progress Report written in English, at the end of the Step 2 in the III  
: 10 copies
3. Draft Final Report and Summary written in English, within four and a half (4.5) months after submission of Final Progress Report of the Step 3 in the III  
: 15 copies
4. Final Report and Summary written in English, within four (4) months after the receipt of comments on the Draft Final Report by NIST  
: 30 copies

MINUTES OF MEETING  
ON  
IMPLEMENTING ARRANGEMENT  
FOR  
THE FEASIBILITY STUDY  
ON  
THE ESTABLISHMENT OF THE POWDERED ACTIVATED  
CARBON PLANTS IN THE REPUBLIC OF THE PHILIPPINES

Dated: 24 March 1983

For Japan International  
Cooperation Agency



Mr. Kenji Iwaguchi  
Leader, Preliminary Survey Team  
Japan International Cooperation  
Agency

For the National Institute of  
Science and Technology



Dr. Quentin L. Kintanar  
Officer-in-Charge  
Office of the Deputy Director  
National Institute of Science  
and Technology

MINUTES OF MEETINGS

The Japanese Preliminary Survey Team sent by the Japan International Cooperation Agency (JICA) and the National Institute of Science and Technology (NIST) had a series of discussions during the period from 15-24 March 1983 on the implementing arrangements for "The Feasibility Study on the Establishment of the Powdered Activated Carbon Plants" in the Republic of the Philippines signed on 24 March 1983.

In that connection, the following are the main subjects mutually discussed and agreed upon:

- I-1 The NIST strongly requested that necessary equipment, analytical instruments and tools be donated for the technical study of the project.
- I-2 The Japanese Preliminary Survey Team (Team) stated that the Team was not in a position to comment on the above matter, however, promised to convey NIST's request to the Government of Japan.
- II-1 The NIST strongly requested the training of several NIST counterparts of the study in Japan.
- II-2 The Team promised to convey NIST's request to the Government of Japan and will exert its best efforts for the realization of the request.
- III-1 The Team requested NIST to identify project areas of high priority.
- III-2 The NIST at the moment proposed the following 6 areas:

<u>Area</u>	<u>No. of sites</u>
Mindanao region	2
Northern Luzon region	1
Bicol region	1
Southern Luzon region	1
Visayas region	1
- IV-1 The Japanese Preliminary Survey Team requested for NIST's full cooperation in making the necessary preparations before the arrival of the feasibility study team, especially in making arrangements for the raw materials, laboratory space and office needed for the project.
- IV-2 The NIST assured the Team to do its utmost best to comply with the Team's request.



## MINUTES OF MEETINGS

The Japanese Preliminary Survey Team sent by the Japan International Cooperation Agency (JICA) and the National Institute of Science and Technology (NIST) had a series of discussions during the period from 15-24 March 1983 on the implementing arrangements for "The Feasibility Study on the Establishment of the Powdered Activated Carbon Plants" in the Republic of the Philippines signed on 24 March 1983.

In that connection, the following are the main subjects mutually discussed and agreed upon:

- I-1 The NIST strongly requested that necessary equipment, analytical instruments and tools be donated for the technical study of the project.
- I-2 The Japanese Preliminary Survey Team (Team) stated that the Team was not in a position to comment on the above matter, however, promised to convey NIST's request to the Government of Japan.
- II-1 The NIST strongly requested the training of several NIST counterparts of the study in Japan.
- II-2 The Team promised to convey NIST's request to the Government of Japan and will exert its best efforts for the realization of the request.
- III-1 The Team requested NIST to identify project areas of high priority.
- III-2 The NIST at the moment proposed the following 6 areas:

<u>Area</u>	<u>No. of sites</u>
Mindanao region	2
Northern Luzon region	1
Bicol region	1
Southern Luzon region	1
Visayas region	1
- IV-1 The Japanese Preliminary Survey Team requested for NIST's full cooperation in making the necessary preparations before the arrival of the feasibility study team, especially in making arrangements for the raw materials, laboratory space and office needed for the project.
- IV-2 The NIST assured the Team to do its utmost best to comply with the Team's request.

MEMBERS OF THE FEASIBILITY STUDY TEAM

<u>Name</u>	<u>Belongs to</u>	<u>Function in the Study</u>
Dr. Shigeo Ueki	Japan Consulting Institute	Leader of F/S Team, Study Supervision, Financial and Economic Evaluation
Mr. Yoichiro Kobayashi	- ditto -	Technical Supervision, Process Study, Plant Designing
Dr. Mutsuo Kitagawa	Society of Activated Carbon Research	Product Market Research
Mr. Keiya Kobayashi	Japan Consulting Institute	Raw Materials Investi- gation

**MEMBERS OF THE TEST TEAM**

**GOVERNMENT INDUSTRIAL DEVELOPMENT LABORATORY, HOKKAIDO**

Dr. Katsuji Ishibashi	Leader of Test Team Senior Research Chemist, 2nd Div., GIDLH, AIST, MITI
Mr. Yoshio Noda	Senior Research Chemist, 2nd Div., GIDLH, AIST, MITI
Mr. Hideo Hosoda	Senior Research Chemical Engineer, 3rd Div., GIDLH, AIST, MITI
Mr. Toshio Ogata	Senior Research Chemist, 2nd Div., GIDLH, AIST, MITI
Mr. Katsutoshi Yamada	Research Chemist, 2nd Div., GIDLH, AIST, MITI

**HOKUETSU CARBON INDUSTRIES CO., LTD.**

Mr. Shoichi Adachi	Supervisor
Mr. Hajime Sugai	— ditto —
Mr. Minoru Sugai	— ditto —
Mr. Shirushi Sugai	Senior Operator, Activation
Mr. Hitoshi Kuwagaki	Senior Analyst
Mr. Kaoru Matsumura	Construction Specialist
Mr. Choji Sato	Operator
Mr. Yukio Watanabe	— ditto —
Mr. Toshinori Asuka	— ditto —
Mr. Shigeo Asai	— ditto —
Mr. Yoshinori Sasaki	Analyst
Mr. Katsumi Tamura	Operator
Mr. Tomio Uoji	— ditto —

**MEMBERS OF THE PHILIPPINE COUNTERPARTS  
NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY**

1. Dr. Filemon A. Uriarte — Director
2. Mrs. Violeta P. Arida — Program Coordinator  
— Supervising Res. Specialist
3. Mrs. Ofelia G. Atienza — Senior Science Research Specialist
4. Mr. Albert R. Caballero — Sci. Res. Specialist II
5. Mr. Teresito A. Quilao — Sci. Res. Specialist II
6. Miss Corazon P. Guce — Sci. Res. Specialist I
7. Mr. Delfin L. Pugal — Sci. Res. Specialist I
8. Mrs. Josie L. Pondevida — Sci. Res. Specialist I
9. Miss Leonora P. Gelera — Sci. Res. Specialist II
10. Miss Medelyn Manalo — Sci. Res. Specialist I

ITINERARY OF F/S TEAM

February 1984

- 6 (Mon) Lv. Tokyo, Ar. Manila
- 7 (Tue) Meeting with NIST and NSTA
- 8 (Wed) Visit to JICA, Japanese Embassy and JETRO  
Meeting with NIST
- 9 (Thu) Survey at BOI, PHILSUCOM and BOI
- 10 (Fri) Survey at PCA, IDC and UA  
Meeting with NIST
- 11 (Sat) Internal Arrangement
- 12 (Sun) Lv. Manila, Ar. Cagayan de Oro
- 13 (Mon) Survey at P.N. Roa, MVC, PAC and MCCI
- 14 (Tue) Lv. Cagayan de Oro, Ar. Davao  
Survey at C.Alcantara and Tanaka Phil.
- 15 (Wed) Survey at PJAC, BFD, Sawmills and City Hall  
Visit to Japanese Consulate Office
- 16 (Thu) Survey at Valderrama
- 17 (Fri) Lv. Davao, Ar. Bacolod  
Survey at PHILSUCOM
- 18 (Sat) Lv. Bacolod, Ar. Manila
- 19 (Sun) Internal Arrangement
- 20 (Mon) Lv. Manila, Ar. Santiago, Isabela  
Survey at Sawmills
- 21 (Tue) Lv. Santiago, Ar. Manila
- 22 (Wed) Survey at PCA, PHILSUCOM and NEDA
- 23 (Thu) Survey at BOI and Taisei Const.
- 24 (Fri) Survey at UCAP, PRC, BFD, MWSS and LWUA
- 25 (Sat) Two Members Leave Manila for Tokyo  
Internal Arrangement
- 26 (Sun) Internal Arrangement
- 27 (Mon) Inauguration of the Activated Carbon Pilot Plant

Feb. 28	(Tue)	Lv. Manila, Ar. Daet Survey at BFD and Sawmills
	29 (Wed)	Lv. Daet, Ar. Manila Survey at RMC and Coir Fiber Plants
Mar. 1	(Thu)	Survey at Sawmill, BFD and BOI
	2 (Fri)	Meeting with NIST
	3 (Sat)	Preparation of Progress Report
	4 (Sun)	Preparation of Progress Report
	5 (Mon)	Reporting to NIST, JICA and Japanese Embassy
	6 (Tue)	Lv. Manila, Ar. Tokyo
May 1984		
	22 (Tue)	Lv. Tokyo, Ar. Manila Meeting with JICA and NIST
	23 (Wed)	Lv. Manila, Ar. Davao Survey at Sawmills
	24 (Thu)	Meeting with C.Alcantara and Sons Inc. to procure sawdust Survey at Sawmill
	25 (Fri)	Meeting with Shipping Company
	26 (Sat)	Internal Arrangement
	27 (Sun)	Lv. Davao, Ar. Manila
	28 (Mon)	Meeting with Industries Development Corp. to procure sawdust
	29 (Tue)	Meeting with NIST
	30 (Wed)	Visit to JICA and Japanese Embassy
	31 (Thu)	Lv. Manila, Ar. Tokyo

Sept. 1984

- 4 (Tue) Three Members leave Tokyo for Manila  
Meeting with JICA and Japanese Embassy
- 5 (Wed) Meeting with NIST and Test Team
- 6 (Thu) Survey at Central Bank, Ministry of Labor and  
Office of the Prime Minister
- 7 (Fri) Survey at PAGASA, Development Bank, TRC and BOI
- 8 (Sat) Internal Arrangement
- 9 (Sun) Two Members leave Manila for Davao
- 10 (Mon) Meeting with NSTA Davao  
Visit to Japanese Consulate Office  
Survey at Sawmill and Davao City Hall  
Meeting with JICA  
Survey at BFD, Ministry of Trade and Industry,  
and BOI
- 11 (Tue) Survey at Davao City Water District  
Observation of Plant Sites
- 12 (Wed) Survey at Davao Light & Power Co., NPCC Davao, and  
Ministry of Labor Davao  
Survey at NPCC, Ministry of Finance and Bureau  
of Customs  
Survey at National Pollution Control Commission,  
Ministry of Finance and Bureau of Customs
- 13 (Thu) Survey of Plant Sites  
Survey at NEDA, National Food Auth.  
Meeting with NIST
- 14 (Fri) One Member leaves Osaka for Manila  
Survey at SPDA and JM
- 15 (Sat) Two Members leave Manila for Davao  
Meeting with NSTA Davao
- 16 (Sun) Observation of Plant Sites
- 17 (Mon) Survey at Davao Sugar Central Co. and Davao City Hall  
Survey at Construction Co.
- 18 (Tue) Survey at Sasa Wharf, Legaspi Oil Co., Inc. and SPDA
- 19 (Wed) All Members leave Davao for Manila
- 20 (Thu) Survey at Crystal Oil Mfg. Corp.  
Meeting with NIST

Sep. 21 (Fri) Survey at Coca-Cola Calamba and San Pabulo Mfg. Co.  
Meeting with JICA and NIST

22 (Sat) Preparation of Progress Report

23 (Sun) Preparation of Progress Report

24 (Mon) Survey at Procter & Gamble PMC  
Meeting with NIST  
Courtesy Call to Minister of NSTA

25 (Tue) Survey at Construction Co., United Laboratories Inc.  
and Victoria Milling Co., Inc.

26 (Wed) Preparation of Progress Report  
Meeting with NIST

27 (Thu) Submit Progress Report to NIST, JICA and  
Japanese Embassy  
Survey at Labor & Statistics Service

28 (Fri) Lv. Manila, Ar. Tokyo



ITINERARY OF TEST TEAM

Jan.	1984			
	12	(Thu)	Lv. Tokyo	Ar. Manila
				Erection
Feb.	4	(Sat)		
				Test
Mar.	6	(Tue)	Lv. Manila	Ar. Tokyo
May	22	(Tue)	Lv. Tokyo	Ar. Manila
				Procurement of Sawdust
May	31	(Thu)	Lv. Manila	Ar. Tokyo
				Carbonization
Sept.	8	(Sat)	Lv. Manila	Ar. Tokyo
Oct.	10	(Wed)	Lv. Tokyo	Ar. Manila
				Carbonization and Continuous Run of Activation
Dec.	14	(Fri)	Lv. Manila	Ar. Tokyo

LIST OF ORGANIZATIONS VISITED AND PERSONS INTERVIEWED

(1) List of Organizations Visited

- National Institute of Science and Technology
- National Science and Technology Authority
- Tanaka Philippines Inc.
- Japanese Embassy Manila
- Japan International Cooperation Agency, Manila
- Japan External Trade Organization, Manila
- Bureau of Forest Development
- Philippine Sugar Commission
- Board of Investments
- Philippine Coconut Authority
- Industries Development Corp.
- Union Ajinomoto Inc.
- P.N. Roa Enterprise
- Maria Christina Chemical Industries Inc.
- Mabuhay Vinyl Corporation
- Pacific Activated Carbon Co., Inc.
- C. Alcantara & Sons Inc.
- South Bay Lumber Co., Inc.
- Davao Gulf Lumber Corporation
- Bureau of Forest Development, Region 11
- NSTA, Davao
- Japanese Consulate Office Davao
- Davao City Hall
- Philippine Japan Activated Carbon Co.
- Valderrama Lumber Mftrs. Co., Inc.
- Philippine Sugar Commission, Visayas and Mindanao

- CALINOG Sugar Refinery
- Growers Association of Ipil-Ipil in Negros
- Green Valley Timber Corp.
- Timber Exports Inc.
- United Coconut Association of the Philippines, Inc.
- Philippine Refinery Company
- Manila Waterworks & Sewage System
- Local Water Utilities Administration
- Bureau of Forest Development, Daet
- Mt. Makisig Wood Products
- Republic Hardwood Inc.
- RMC Commercial Corp.
- Coirflex Philippine Inc.
- Soriano Fiber Industries
- East Asia Sawmill Corp.
- Consolidated Plywood Industries
- Central Bank of the Philippines
- Ministry of Labor, National Capital Region
- Office of the Prime Minister
- Development Bank of the Philippines
- Technology Resource Center
- Philippine Atmospheric Geophysical and Astronomical Services  
Administration
- Davao City Water District
- Davao Light and Power Co.
- Regional Pollution Control Office (NPCC-Reg. XI)
- Ministry of Labor and Employment Regional Office
- Southern Phils. Development Authority
- University of Mindanao

- Crystal Oil Mfg. Corp.
- Coca-Cola Calamba
- San Pubulo Mfg. Co.
- Procter and Gamble PMC
- Asian Construction and Development Corp.
- National Pollution Control Commission
- Ministry of Finance
- Bureau of Customs
- National Economic Development Authority
- National Food Authority
- Davao Sugar Central Co., Inc.
- Sasa Wharf
- United Laboratory
- Victorias Milling Co., Inc.
- Labor Statistic Service, Ministry of Labor & Employment
- Legaspi Oil Ind.

(2) Persons Interviewed with the Study Team

<u>Name</u>	<u>Title</u>
<u>National Institute of Science and Technology</u> Dr. Felimon A. Uriarte, Jr. Mrs. Violeta P. Arida	Director Program Coordinator
<u>National Science and Technology Authority</u> Dr. Emil Q. Javier Dr. Quintin L. Kintanar	Minister Deputy Minister
<u>Tanaka Philippines Inc.</u> Mr. Tamaki Itoh Mr. Mac S. Ancog	President Sales Manager
<u>Bureau of Forest Development</u> Mr. Rogelio B. Baggayan	Chief: Planning and Evaluation Div.
<u>Philippine Sugar Commission</u> Mr. Marcial T. Perez	Head, Production Regulation and Control Dept.
<u>Board of Investments</u> Mrs. Glory Lleander-Chanco Mrs. Gloria D. Santos	Organic Chemical Industries Dept.
<u>Philippine Coconut Authority</u> Mr. Elazar Tejano Mr. Raul Peralejo	Industrial Research & Market Development Branch
<u>Industries Development Corp.</u> Mr. Jose Ong Mr. Joselito D. Ong	President
<u>Union Ajinomoto, Inc.</u> Mr. Takashi Koizumi	Factory Superintendent
<u>P.N. Roa Enterprise</u> Mr. Roa	Ex. Congress
<u>Maria Christina Chemical Industries Inc.</u> Mr. Leynaldo G. Lomarda Mr. Camilo L. Penaco	Plant Manager
<u>Mabuhay Vinyl Corporation</u> Mr. Ricardo B. Aves Mr. Ramon S. Lepena	Plant Manager Technical Superintendent
<u>Pacific Activated Carbon Co., Inc.</u> Mr. Rene Precillas	Personnel Officer
<u>C. Alcantara &amp; Sons, Inc.</u> Mr. Juanito L. Calolot	VP-Operations

<u>Name</u>	<u>Title</u>
<u>RMC Commercial Corp.</u> Mr. Eusebio L. Baldoz	Manager
<u>Coirflex Philippine Inc.</u> Mr. Paraon	Engineer
<u>Soriano Fiber Industries</u> Mr. Victorino Becina	Operation Manager
<u>East Asia Sawmill Corp.</u> Mr. Delfin Lee	General Manager
<u>Central Bank of the Philippines</u> Mr. Virgilio V. Gaudinez Mr. J. Antonio E. Muñoz	Assistant Director, MEDIAD Director, Deputy Head, APEX
<u>Ministry of Labor, NCR</u> Mr. Severo M. Pucan	Director
<u>Office of the Prime Minister</u> Mr. Ricardo J. Kwek	Deputy Secretary General
<u>Development Bank of the Philippines</u> Ms. Ofelia J. Castell	Executive Officer, Industrial Projects Dept. 1
<u>Technology Resource Center</u> Mr. J. Antonio P. Honrado	Director
<u>PAGASA</u> Mr. Manuel C. Bonjoc Mr. Ernesto V. Calpo	Director (NAGADO) Director (NAGO)
<u>Davao City Water District</u> Mr. Iluminado P. Quinto Mr. Wilfred C. Yamson	General Manager Chief, Operation Division
<u>Davao Light and Power Co.</u> Mr. Nemesio Camposano	Billing and Collection Supervisor
<u>Regional Pollution Control Office</u> Mr. Gregorio T. Esfrada	Regional Pollution Control Officer
<u>Ministry of Labor and Employment Regional Office</u> Mr. Atty. Eugenio I. Sagmit, Jr. Mr. Atty. Felizardo T. Serapio Mrs. Brenda L. Villafuerte	Regional Director Chief, Labor Relations Division Chief, Employment Promotion Div.
<u>Southern Phils. Development Authority</u> Mr. Col Santos C. Payunio Mr. Esteban A. Pabrua	Manager, Corporate Planning Group Manager, Administration Dept.

<u>Name</u>	<u>Title</u>
<u>South Bay Lumber Co., Inc.</u> Mr. Emiliano K. Alvarez	Exec. Vice Pres. & Gen. Mgr.
<u>Davao Gulf Lumber Corporation</u> Mr. Bienvenido S. Estanislao	Sawmill Plant Manager
<u>NSTA, Region XI</u> Mrs. Madel Moran Morados Mr. Warthur Campugan	Regional Coordinator Administrative Officer
<u>BFD, Region XI</u> Mr. Roger Cantuba	Forester
<u>Davao City Hall</u> Mr. Elias B. Lopez Mr. Cesar R. Nuñez Mr. Felipe B. Capli Mr. Reynaldo C. Ledesma	Mayor City Secretary City Development Coordinator City Planning and Development Office
<u>Philippine Japan Activated Carbon Co.</u> Mr. Sueichi Matsuura	Executive Vice President and General Manager
<u>Valderrama Lumber Mftrs. Co., Inc.</u> Mr. Ricardo S. Funa	Industrial Division Manager
<u>PHILSUCOM, Visayas and Mindanao</u> Mr. Eduards F. Gamboa Mr. Salvador M. Legaspi	General Manager Technical Economic Consultant
<u>Gamboa Hermanos, Inc.</u> Mr. Jose R. Deen	Field Manager
<u>Green Valley Timber Corp.</u> Mr. George Ong	President
<u>United Coconut Association of the Philippines, Inc.</u> Mr. Leonardo F. Ignacio Mis. Yvonne T. Vigo Agustin	Executive Secretary Publication Head
<u>Philippine Refinery Company</u> Mr. Ernesto Ortiz-Luis Mr. Julio Cesar Locsin	
<u>Manila Waterworks &amp; Sewage System</u> Mr. Lauro G. Salonga	Division Manager (Laboratory)
<u>Local Water Utilities Administration</u> Mr. Carlos C. Leño, Jr.	General Manager
<u>BFD, Daet</u> Mr. David S. Serrano	District Forester
<u>Republic Hardwood, Inc.</u> Mr. Ong Peng Lee	General Manager

<u>Name</u>	<u>Title</u>
<u>University of Mindanao</u> Mr. Pedro E. Torres	Vice-President
<u>Crystal Oil Mfg. Corp.</u> Mr. Peter Co	Supervisor
<u>Coca-Cola Calamba</u> Mr. Nestor B. Gamez	Production Superintendent
<u>San Pabulo Mfg. Co.</u> Mr. Rodolfo Rebueno	General Manager
<u>Procter and Gamble PMC</u> Mr. Ver Sabriel	Department Manager
<u>Asian Construcion and Development Corp.</u> Mr. Edgardo H. Angeles Mr. Jaime O. Directo Mr. Celso M. Ariunday	President Regional Manager Manager
<u>National Pollution Control Commission</u> Mr. Pedro P. Viray	OIC. Office of the Deputy Commission For Standard & Monitoring
<u>Ministry of Finance</u> Mr. Bayami Quilala, Jr.	Revenue Service
<u>Bureau of Customs</u> Mr. Titus B. Villanueva	
<u>National Economic Development Authority</u> Mr. Jesus M. Suñga Mrs. Remedios R. de Leon	Director
<u>National Food Authority</u> Mr. Leodegario R. Bascos, Jr.	Senior Executive Assistant Technical Research & Extension Directorate
<u>Davao Sugar Central Co., Inc.</u> Mr. Salvador M. Deles, PME	General Manager
<u>Sasa Wharf</u> Mr. Edlardo V. Estariya Mr. Francis A. Calatrava	Harbor Master Corporate Attorney
<u>United Laboratory</u> Dr. Rogelio P. de Leon	
<u>Victorias Milling Co., Inc.</u> Mr. Eduardo R. de Luzuriaga	Consultant



<u>Name</u>	<u>Title</u>
<u>Labor Statistic Service</u> Ms. Genoveva L. Santos	
<u>Legaspi Oil Ind.</u> Mr. Agustin B. Zuluaga	AVP-Branch Manager



## Appendix 2A-1 ACTIVATED CARBON INDUSTRY

### 2.1 Activated Carbon Industry

#### 2.1.1 History of Activated Carbon Industry in U.S.A. and Europe

The history of activated carbon started with the vegetable- and animal-based char such as wood char, bone char and blood char as medical. Later, discovery that these char can be used for taste improvement, deodorization and decoloration of drinking water, foods and seasonings further expanded their field of applications. However, these char were insufficient in adsorption power, so in the face of growing demands for products of ever higher quality levels, concepts came to be introduced in connection with careful selection of raw materials, adsorption phenomenon and activation process, introducing research for the development of technologies for quality improvement and for the practical use.

The progress in adsorption technologies for utilizing substances such as activated carbon, bone char and ion exchange resins, as well as mass production and regeneration technologies relating to these adsorbents, have a close relationship with the food processing industry, in particular the sugar refining industry.

In about 1794, wood char was used for the decoloration of sugar syrup by a sugar refinery in London, followed in 1812 with the introduction of bone char. The adsorption process was a flow system, and spent char was reused after regeneration by heating. However, with wood char and bone char which are obtained by heating and carbonizing the raw material, the adsorption power is poor. If the adsorption performance is poor, a larger quantity will have to be used, with the result that a large loss of sugar will be sustained owing to the adhesion of sugar syrup on adsorbent grains.

Against this backdrop, the development of some high-performance activated carbon capable of displaying excellent decoloration effect with a small quantity and without accompanying much product loss came to be demanded.

Meanwhile, the outbreak of World War I in 1915 triggered a demand for large quantities of activated carbon for use in gas masks to remove poison gas, leading to intensive research and development of manufacturing technologies. Especially during 1920–1923 after World War I, rapid progress was achieved in connection with activated carbon, and new fields of

industrial applications were developed as for refining mineral oils, vegetable oils, sugar and chemicals such as glycerine, among which sugar refining came to assume 10--20% of the total volume of consumption of activated carbon.

After termination of World War I, the United States came to assume the world's industrial leadership, and significant progress was achieved in the research, manufacture and utilization of activated carbon.

Table 2A-1-1 shows the history of the activated carbon industry in U.S.A. and Europe.

### **2.1.2 History of Activated Carbon Industry in Japan**

In Japan, vegetable- and animal-based chars have been used as medicine from ancient times. And, records show that wood char was being used as water purifying agent in as early as about 1860.

It was from about 1910 that activated carbon came to be imported into Japan for use in the manufacture of medicines and for sugar refining.

Research on activated carbon manufacture began in Japan from about the time of World War I, when patent rights pertaining to the manufacture of activated carbon came to be registered as a result of research, triggered largely by factors such as the interruption of import of medical supplies from Western countries, soaring prices, and the demand for a large quantity of activated carbon for gas masks.

Table 2A-1-2 shows the history of the Japanese activated carbon industry.

## **2.2 Kinds of Activated Carbon and Their Properties**

### **2.2.1 Classification of Activated Carbon**

Activated carbon assumes various characteristics (pore structure, adsorption capability, strength, size, etc.) depending on its specific raw material and manufacturing process. That is, a deep mutual relationship exists between its application and the specific kind of raw material and manufacturing process which are adopted.

**Table 2A-1-1 HISTORY OF ACTIVATED CARBON INDUSTRY  
IN USA AND EUROPE**

- o Use of wood char etc. as medicine (B.C. 1550)
- o Drinking water refining with wood char (B.C. 200)
- o Discovery of adsorption phenomenon (1773)
- o Decoloration of liquids with wood char (1785)
- o Sugar refining with wood char (1794)
- o Decoloration of liquids with animal char (1811)
- o Sugar refining with bone char (1812)
- o Regeneration of used bone char in sugar refining (1828)
- o Research on steam activation process (1856)
- o Research on phosphoric acid activation process (1868)
- o Invention of wood char gas mask (1872)
- o Manufacture of bone char by rotary furnace (1880)
- o Patents registered for chemical and steam (gas) activation process (1900)
- o Manufacture of powdered activated carbon (1909)
- o World War I
- o Manufacture of activated carbon for gas masks
- o Monomolecular layer adsorption theory introduced
- o Manufacture of activated carbon by use of pulp mill waste liquor
- o Use of activated carbon to sugar refining industry
- o Service water treatment with powdered activated carbon (1930)
- o Service water treatment with granular activated carbon (1930)
- o World War II (1939)
- o Manufacture of crushed activated carbon from bituminous coal
- o Invention of 2-stage fluidized bed activation furnace (1948)
- o Multi-layer fluidized bed furnace
- o Sale of cigarette filter (1954)
- o Solvent recovery process by multi-layer fluidized bed (1960)
- o Regeneration of waste activated carbon
- o Treatment of sewerage water with activated carbon

Table 2A-1-2 HISTORY OF ACTIVATED CARBON INDUSTRY IN JAPAN

- o Research on adsorption started in universities and research institutes (1915)
- o Patents registered on chemical activation process (1915)
- o Patents on gas activation process (1921)
- o Research on gas masks started (1923)
- o Patent on zinc chloride activation process
- o Activated carbon for medicine imported (1924)
- o Manufacture of activated carbon started (1925)
- o "Activated Carbon" published (1925)
- o Manufacture by zinc chloride process started
- o Manufacture by steam process started (1932)
- o Gas masks manufactured by rotary kiln with steam activation process (1932)
- o Solvent recovery process (1935)
- o Fisher process oil synthesis (adsorption) plant put in operation (1941)
- o Activated carbon production amounted to 1,600 tons/year (1942)
- o Activated carbon production reduced to 200 tons/year
- o Demand increased for powdered activated carbon for sugar refining, manufacture of mono-sodium glutamate
- o Fluidized activation process commercialized (1949)
- o Process for manufacture of activated carbon from lignite (1953)
- o Service water treated with powdered activated carbon (1960)
- o Activated carbon production amounted to 10,000 tons (Powdered), 1,600 tons (Granular) (1961)
- o Sugar refined with granular activated carbon (1963)
- o Multi-stage furnace introduced, bone char recovered (1965)
- o "Adsorption" published (1965)
- o Filter cigarette Seven Stars sold (1969)
- o Molecular sieve carbon manufacture
- o Pelletized granular activated carbon from coal (1971)
- o Stirred fluidized bed furnace (1973)
- o Pelletized granular activated carbon from petroleum pitch (1973)
- o "Activated carbon industry" published (1974)
- o Research on low temperature regeneration by air oxidation (1976)
- o Fibrous activated carbon commercialized (1975)
- o Multi-stage fluidized bed water treatment process developed (1981)

Table 2A-1-3 CLASSIFICATION OF ACTIVATED CARBON

Classification	Description
Carbonaceous raw materials	<ul style="list-style-type: none"> <li>a. Plant: wood, nuts shell, etc.</li> <li>b. Fossil fuel: coal, petroleum</li> <li>c. Others: bone, blood, etc.</li> </ul>
Manufacturing process	<ul style="list-style-type: none"> <li>a. Gas or steam activation</li> <li>b. Chemical activation</li> <li>c. Others: thermal decomposition, etc.</li> </ul>
Shape	<ul style="list-style-type: none"> <li>a. Powdered</li> <li>b. Granular</li> <li>c. Crushed</li> <li>d. Pelletized (spherical or cylindrical)</li> <li>e. Fiber, cloth, paper, honeycomb, microcapsule</li> <li>f. Wet</li> </ul>
Fresh or regenerated	<ul style="list-style-type: none"> <li>a. Fresh</li> <li>b. Regenerated</li> </ul>
Impregnated with additive, or not	<ul style="list-style-type: none"> <li>a. (Usual)</li> <li>b. Additive: acids, alkalis, catalytic metal, germicidal metal</li> <li>c. Compound: mixture with silica gel, etc.</li> </ul>
Use	<ul style="list-style-type: none"> <li>a. Liquid phase: brewing, chemicals refining, service water, waste water, chromatograph, medicine, etc.</li> <li>b. Gaseous phase: solvent recovery, gas masks, deodorization, air conditioning, etc.</li> <li>c. For medicine</li> </ul>

Accordingly, activated carbon can be classified from various aspects, as shown in Table 2A-1-3.

1) Classification by Kind of Raw Material

Various kinds of carbonaceous materials are available for manufacturing activated carbon, as shown in Table 2A-1-4. Activated carbon consists principally of carbon, so materials which provide carbon residue of low ash content by heating are usable as raw material. Table 2A-1-4 shows the various kinds of raw materials that are usable.

Sawdust, sawdust char, wood char, coconut shell, coconut shell char, lignite, bituminous coal, anthracite and pitch are available for commercial production. Fibrous activated carbon, which is a special type of activated carbon can be manufactured from polyacrylonitrile, a synthetic high polymer, or rayon which is a regenerated cellulose.

Regarding granular activated carbon, charcoal had been used as the raw material hitherto, but recently the principal raw materials are imported coconut shell (or its char), imported coal (sometimes used in a mixture with domestic coal), petroleum pitch and others.

Table 2A-1-4 RAW MATERIALS FOR ACTIVATED CARBON

Botanical Matter	Fossil Carbonaceous Matter	
Wood-based	Coal-based	Petroleum-based
Wood (Sawdust) Wood char Sawdust char Fruit shell char (Coconut shell, Palm shell)	Peat Turf Lignite Brown coal Sub-bituminous coal Bituminous coal Anthracite	Petroleum pitch Petroleum coke
Regenerated fiber		Plastics Synthetic fiber Carbon fiber
(Binder) Pulp waste liquor	(Binder) Coal tar	Petroleum pitch



## 2) Classification by Manufacturing Process

Activated carbon may be classified according to its manufacturing process -- the gas activated carbon that is obtained by reacting carbonaceous matter with air, steam or carbon dioxide gas, or a high-temperature combustion gas containing these gases; the chemically activated carbon that is obtained by treating sawdust with zinc chloride solution, followed with activated by heating; and other types of activated carbon which are obtained through activation by carbonization or thermo-decomposition.

## 3) Classification by Shape

Activated carbon can also be classified according to the shape --- powdered, granular and others. Powdered and granular activated carbon products are available in various different particle sizes. Granular activated carbon is further divided into crushed type coconut shell char, palm shell char or crushed wood char and pelletized type (obtained by pelletizing pulverized carbonaceous materials into spherical or cylindrical pellets). Even with the same granular type activated carbon, it is available in various different size distribution and hardness, making it necessary to select the optimum type of activated carbon according to its raw material, manufacturing process and the specific purpose for which it is to be used.

Fibrous activated carbon features large surface area and high air permeability, so while it is rather expensive, it is suitable for adsorbing and removing diluted substances existing in gaseous phase environments. This type of activated carbon is available in fabric form or paper form. In the latter case, there are such cases as ordinary paper is given a coating of powdered activated carbon, or it is manufactured mixed with activated carbon in paper making.

As for honeycomb type activated carbon and fine, macaroni-shaped activated carbon, their properties lie in between those of granular and fibrous activated carbon and feature handling ease and relatively high adsorption capacities and speeds.

Activated carbon is also available in capsules. Collapsible pelletized activated carbon, when used in liquid phase environments, is disintegrated into pulverized activated carbon, which makes its handling convenient.

Table 2A-1-5 offers a comparison of the characteristics of powder, granular and fibrous activated carbon.

Powdered activated carbon is normally used in disposable form, and not regenerated

**Table 2A-1-5 COMPARISON OF CHARACTERISTICS OF POWDERED,  
GRANULAR AND FIBROUS ACTIVATED CARBON**

Item	Powdered activated carbon	Granular activated carbon	Fibrous activated carbon
Contact surface area	Large	Small	Medium
Method of use	Batch	Continuous	Continuous
Method of operation	Stirred contact	Flow through bed	Flow through bed
Recycling or not	Disposed after use*	Regeneration and Reactivation	Regeneration and Reactivation
Working environment	Dust control is neces- sary	No trouble	No trouble
Disposal of spent carbon	Necessary*	Unnecessary	Unnecessary
Operation control	Rather complicated	Easy	Easy
Application scale	Small and Extremely Large	Medium and Large	Medium and Large

\* Regeneration (or reactivation) is costly at present but under development.

owing to the high costs that would be involved. On the other hand, granular activated carbon is generally reutilized by regeneration, which is a major factor for its growing demand in recent years.

#### 4) Classification by Existence of Additives

To cope with substances against which activated carbon is incapable of amply displaying its adsorbability independently, the substance to be adsorbed is changed by chemical reaction and adsorbed by activated carbon. Activated carbon which is added with acid, alkali or catalyst is known as impregnated activated carbon. It displays excellent deodorizing effect especially with respect to foul gases containing hydrogen sulfide, mercaptan, ammonia, etc. Activated carbon adsorbing carbon monoxide has been in use from long ago, which also belongs to this category of impregnated activated carbon. Demand for this type of activated carbon is increasing in recent years for use in deodorization at sewerage treatment facilities and in chemical plant exhaust gas treatment systems.

## 2.2.2 Properties of Activated Carbon

### 1) Elementary Composition of Activated Carbon

Activated carbon consists primarily of carbon, or 90% of carbon on an ash-free basis. Constituent elements other than carbon are hydrogen, oxygen, nitrogen and organic sulfur. The contents of these elements, as with the ash content, will differ according to raw material and the conditions under which the activated carbon is manufactured. In general, activated carbon produced at high temperature and treated over a long period of time has a high ash content.

However, when activated carbon comes into contact with the free oxygen existing in the atmosphere even at a comparatively low temperature during its manufacturing process and after its manufacture, its oxygen content may be increased and hydrogen content decreased, with the result that the activated carbon's elementary composition may be changed, which will change or deteriorating the properties of the activated carbon itself. Incidentally, increasing the activated carbon's oxygen content through oxidation treatment is known to improve the activated carbon's phenol adsorption capability.

Table 2A-1-6 shows an example of elementary compositions of activated carbon on a dry, ash-free basis. The ash content (mineral inorganic matter) may derive from raw material or get mixed in the process of manufacture of activated carbon, and differs widely depending on the specific brand. Ash can be reduced by water-washing or by acid-washing, but activated carbon is usable without washing when put to applications in which the ash content poses no problem.

Gas mask activated carbon for adsorbing carbon monoxide has been used from long ago as an impregnated activated carbon added with cuprous salt, but today the impregnated activated carbon containing various kinds of additives such as acids, alkalis and catalytic metals has come to be used popularly as deodorizing activated carbon. Alkali impregnated activated carbon is effective for the adsorption of acidic gases such as hydrogen sulfide, while acids impregnated activated carbon displays excellent adsorbability with respect to substances such as ammonia and amine. These admixtures are regarded as added or mixed substances from the standpoint of elementary composition.

Chemical process activated carbon generally contains a high content of ash and water-soluble substances, also much impurities such as chlorides and ferrous substances. On the other hand, gas process activated carbon generally contains a small quantity of impurities (refer to Table 2A-1-7).

Table 2A-1-6 ELEMENTARY COMPOSITION OF ACTIVATED CARBON

(%)

Brand	C	H	O	N	S organic	S inorganic	Ash
A	88.4	7.8	—	0.4	0.14	0.4	32.0
B	94.4	1.1	—	0.62	0.04	0.62	4.3
C	91.7	1.7	—	0.38	0.05	0.38	3.2
D	95.3	0.6	—	0.54	0.43	0.54	1.2
E	87.5	2.2	—	0.39	0.04	0.39	2.0
F	95.8	0.6	2.8	0.8	—	—	24.6
G	93.3	0.9	3.3		0.0	0.0	2.5
H	91.1	0.7	4.5		0.0	0.0	3.7
I	90.9	1.6	6.3		0.0	0.0	1.3
J	92.2	1.7	5.6		1.2	—	0.1

Table 2A-1-7 PROPERTIES AND CHEMICAL COMPOSITION OF COMMERCIAL POWDERED ACTIVATED CARBON

Process		Chemical activation activated carbon	Gas activation activated carbon	
			Water-washed	Non-washed
pH		5.2–6.6	6.0–7.5	9.7–10.4
Methylene blue decoloration value. (mg/g)		60–90	90–140	110–170
Sugar liquor relative efficiency to Suchar Carbon (%)		106–124	92–101	71–96
Impurities (%)	Ferrous Materials	0.01–0.2	0.001–0.02	— 0.02
	Chlorides	0.02–0.6	0.01–0.12	— 0.05
	Sulfates	~ 0.1	~ 0.05	trace
Ash (%)		4.2–13.0	1.1–3.9	1.5–2.4
Water Solubles (%)		0.14–1.6	0.05–0.3	0.34–0.93

## 2) Physical and Chemical Properties of Activated Carbon

Activated carbon is a porous substance characterized by a fine porous structure, and various kinds of activated carbon are available which feature different properties depending on the pore volume, specific surface area, distribution of pore diameters, surface conditions of the pores and the specific kinds and quantities of functional radicals.

Fig. 2A-1-1 shows the distribution of pore diameters of various kinds of activated carbon. Fine pores having diameters of less than 300 Å as the boundary are known as micropores, and pores having larger diameters as macropores. The characteristics of these fine pores are a vital factor that determines the very application to which a certain type of activated carbon is put.

Fig. 2A-1-1 PORE DIAMETER DISTRIBUTION OF VARIOUS ADSORBENT

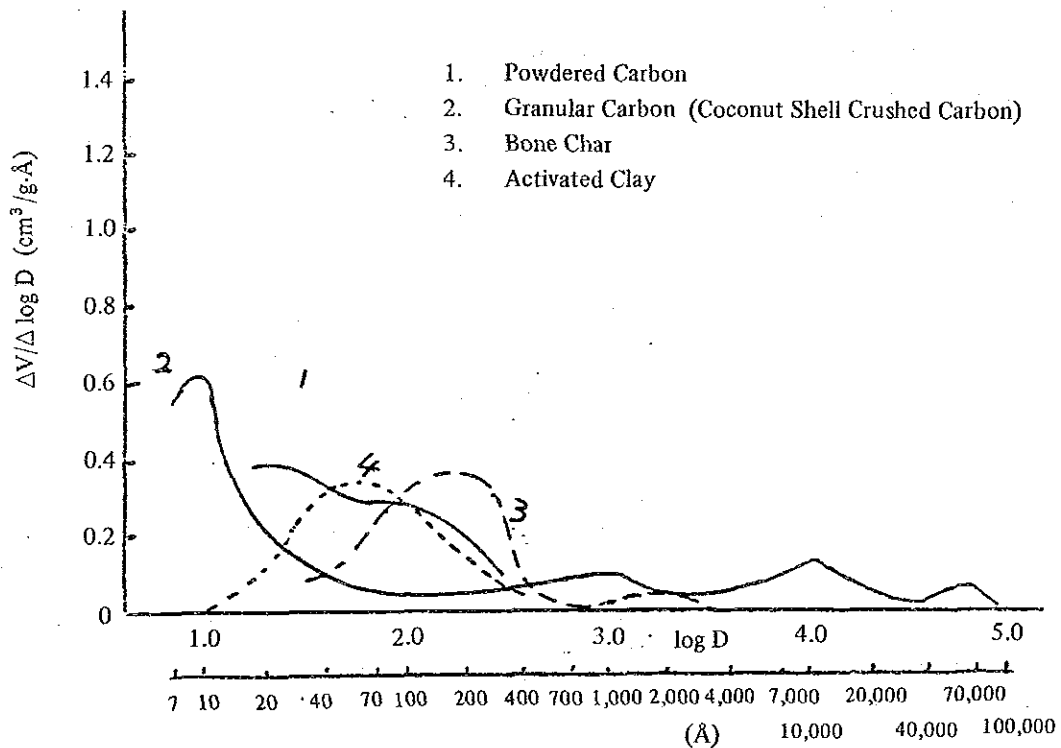


Table 2A-1-8 shows the ranges of pore volumes and specific surface areas of steam process activated carbon and chemical process activated carbon. It is obvious that micropores have a large bearing on the specific surface area, and that the pore volume is larger with zinc chloride process activated carbon.

**Table 2A-1-8 SPECIFIC SURFACE AREA AND PORE VOLUME OF SOME ACTIVATED CARBON**

	Steam Activated Carbon		ZnCl <sub>2</sub> Activated Carbon	
	Pore Volume (ml/g)	Specific Surface Area (m <sup>2</sup> /g)	Pore Volume (ml/g)	Specific Surface Area (m <sup>2</sup> /g)
Micro-pore	0.25–0.6	700–1,400	0.4–0.9	500–1,000
Transitional Pore	0.02–0.2	1–200	0.3–1.0	200–800
Macro-pore	0.20–0.5	0.5–2		

The driving force of adsorption of activated carbon essentially consists of the reversible physical adsorption based on Van der Waals' force and the non-reversible chemical adsorption based on the force of chemical affinity. A state of saturation is brought about when the surfaces of the internal pores of the activated carbon grains are covered with adsorption layer, which indicates the activated carbon's adsorption capacity. The adsorption capacity depends on the inner surface areas of the fine pores and the diameters of capillary tubes of the activated carbon, and adsorption is a phenomenon closely resembling that of condensation. Therefore, it accompanies the evolution of heat that is known as the heat of adsorption and which depends on the adsorbed substance and the adsorption conditions.

Based on the factors described above, a state of equilibrium of adsorption is established.

The characteristics of activated carbon as an adsorbent are summarized as follows:

- i) Activated carbon is a nonpolar and hydrophobic adsorbent, and is highly effective for the adsorption of nonpolar and hydrophobic substances. However, it is also capable of adsorbing polar substances, hydrophilic substances and lyophilic substances.
- ii) It has the largest inner surface area among various adsorbents. The sizes of its fine pores are distributed over a wide range, making its discrimination by molecular diameter more difficult than in the case of the molecular sieves.

Regarding the tendency of adsorption for compounds belonging to the same homolog, molecules having larger molecular weights are easily adsorbed, but that with polymer compounds, larger molecules are not easily adsorbed.

- iii) Having numerous fine pores, it generally displays excellent adsorbability with respect to substances of low concentration.
- iv) Having excellent physical and chemical stability, it can be applied under various conditions. However, it may become unstable depending on its raw material and manufacturing process, with some activated carbon catching fire with ease in the air of 100°C. Therefore, it will be necessary to confirm this point for safety's sake when adopting a new manufacturing process or when changing the conditions of use.
- v) Surface compounds can be formed. So activated carbon is used for catalysts and catalyst carriers.

### 3) Comparison of Properties of Powdered, Granular and Fibrous Activated Carbon

Broadly classified, activated carbon is used in three basic forms -- powdered, granular and fibrous forms, and further in a variety of processed commercial forms for the sake of convenient use.

Powdered activated carbon, excluding exceptional cases, is used for liquid phase adsorption.

Meanwhile, granular activated carbon can be put to a wide range of both gaseous phase and liquid phase applications, and its shape, strength as well as size are selected suitably in conformance with the adsorption conditions of fixed bed, moving bed and fluidized bed or in conformance with the contact conditions of the gases and liquids to be treated.

With fibrous activated carbon, its external surface area lies in between those of powdered and granular activated carbon, so it features the merits of both type of activated carbon. Also, its high void fraction and small pressure loss when passing fluids have the effect of enabling systems to be designed relatively compact.

Table 2A-1-5 shows the characteristics of activated carbon of various forms.

4) Characteristics Required for Activated Carbon Used in Liquid Phase and Gaseous Phase

The following characteristics are required for powdered activated carbon used for liquid phase adsorption:

- i) High adsorption capacity.
- ii) High bulk density that minimizes the storage, transportation and handling volume.
- iii) Minimal loss valuable substances treated by the adsorbent.
- iv) Excellent filtration property.
- v) High purity, small quantities of acid-soluble and water-soluble substance and non-pollution of treated liquids.
- vi) Minimal scattering of dust particles.

Meanwhile, the characteristics required for activated carbon used for gaseous phase adsorption are the following:

- i) High adsorption capacity.
- ii) Appropriate retentivity, ease of desorption when used for the recovery of adsorbate.
- iii) Low resistance to gas penetration.
- iv) High wear resistivity.
- v) Great mechanical strength.
- vi) Retention of adsorbed substance without its deterioration.
- vii) High ignition temperatures.

In adsorption treatment such as in air purification, deodorization and use of gas masks, the adsorbent's retention power is required. A strong retention power will be necessary



even when making adsorbent layers thin and effective. The retention power will depend on the type of adsorptive and activated carbon, and with an adsorbent of strong retention power, desorption will be difficult. This will be inconvenient for recovering adsorptives as valuable substances.

Therefore, activated carbon is designed, manufactured and marketed in various typical brands featuring properties which are suitably matched to specific purposes of use. And it will also be necessary to make slight changes in preparation in accordance with specific user needs.

### **2.3 Manufacture of Activated Carbon**

*Activated carbon featuring different levels of adsorbability can be produced by using different raw materials and adopting different activation processes.*

#### **2.3.1 Construction and Management of Activated Carbon Plant**

Several points will have to be taken fully into consideration when constructing and managing an activated carbon plant, the principal of which are the following:

- (a) Existence of markets having ample sizes commensurate with the plant's economic size.
- (b) The capability of manufacturing activated carbon suitable for specific target applications.
- (c) Product price that would be acceptable on the markets, backed by appropriate raw material and manufacturing costs, sales costs, research and development costs, etc.
- (d) Establishment of production management and quality control system, and capability of supplying activated carbon of uniform quality meeting needs.
- (e) Appropriate timing for commencement of production.
- (f) Specific and extended knowledge relating to activated carbon markets.

Excellent manufacturing technologies involve such factors as raw materials and manufacturing processes selected appropriately for producing activated carbon meeting specific

needs, manufacturing equipment (especially activated furnaces) which are economical and feature minimal trouble and easy maintenance, reasonable material handling facilities and auxiliary equipment, excellent plant operators, and maintenance personnels.

In the initial stage of plant operation, it will be only natural for the actual plant operation rate to be lower than the plant's designed capacity, resulting in high fixed costs.

Also, when operating the plant for various kinds of products with a small lot, a substantial volume of rejectable products will be generated at time of switchover to a product of different specifications, depending on the plant type and structure, with the result that the yield will be decreased to aggravate the plant's expected profitability.

After entering into normal operation, the greatest emphasis should be placed on product quality and cost factors in order to keep the plant's competitive power. This can be achieved by expanding the range of stabilized clients, reduction of capital and personnel costs through mass production, and by securing a stable supply of inexpensive raw materials.

Raw material prices deserve the greatest attention especially at times of high fuel prices. Also, since raw material prices are often influenced by fuel prices in general, the establishment of a separate industry consuming notable quantities of fuel resources near sawdust and coconut shell producing regions will have the effect of raising raw material prices. Consumption by local inhabitants may also constitute a factor.

While the influence of fuel prices on sawdust, the raw material for powdered activated carbon, is expected to be less, due attention should nonetheless be paid to deterioration of plant profitability due to rising of raw material costs.

### 2.3.2 Description of Activation Processes

Various activation processes are reported in scientific literature, and many patents rights exist in connection with activation systems. Among these are the sub-bituminous coal fluidized bed type activation process that is being adopted popularly today (German patent registered by F. Winkler in 1928, commonly known today as the gasification process), and the gas activation processes using sawdust or lignite as the raw material for producing powdered activated carbon.

Regarding granular activated carbon, the basic processes are the rotary kiln process, the Herreshoff furnace process and the fluidized bed process.

Most activation processes are accomplished independently by the basic reaction or by combining basic reactions. That is, thermal decomposition (or carbonization) of carbonaceous raw material and high-temperature activated reaction by oxidizing gases (air, combustion gas, steam or carbon dioxide) are accomplished together with treatments before and after these reactions.

*Descriptions of various activation processes is offered hereunder.*

#### 1) Chemical Activation Process

Carbonaceous raw material is added with dehydrating activation chemicals, then heated to 400–1,000°C (600–700°C in zinc chloride activation process) with air cut off. It is said that these chemicals have the effect of lowering the thermal decomposition temperature, but there is another opinion that they are also claimed to suppress the generation of tar.

A vital conditional factor in this activation process is the weight ratio between activation agent and raw material on dry basis. The influence of this ratio on the porosity of the product is evident from the fact that the volume of salt residue in the carbonized substance is equal to the pore volume opened by extraction of the salt.

Salts such as calcium chloride, magnesium chloride and zinc chloride are effective, but zinc chloride is used commercially.

As the raw material, a carbonaceous substance containing carbohydrates, such as sawdust or peat, is mixed with a concentrated solution of zinc chloride (specific gravity 1.8) at a ratio of 1:1 (for granular activated carbon) or 1:2 (for powdered activated carbon) and dried then heated to a temperature of 600–700°C in a brick-lined rotary kiln.

The gas exhausted from the rotary kiln contains a large quantity of associated zinc chloride vapor. Depending on conditions, 30–65% of zinc chloride is contained in the flue gas. This gas is passed through a condenser to recover the larger part of zinc chloride that is subsequently returned to the activation process for reutilization.

The carbonized substance that is formed consists of a mixture of carbon and zinc chloride, and is processed by leaching with water or hydrochloric acid, followed with extraction, water-washing and drying to obtain the final product.

The powdered activated carbon thus obtained consists of particles having a distribu-

tion of fine pores of large diameters compared with those obtained by the steam or gas activation process to be described subsequently, and is effective for applications involving heavy adsorption loads as in the decoloration of caramel.

Fig. 2A-1-2 shows the process for manufacturing zinc chloride process powdered activated carbon. The disadvantage of this manufacturing process is that much costs will be required for preserving the living environments near the manufacturing plant as well as good working environments when environmental laws and regulations become severe.

Fig. 2A-1-2 ZnCl<sub>2</sub> ACTIVATION PROCESS

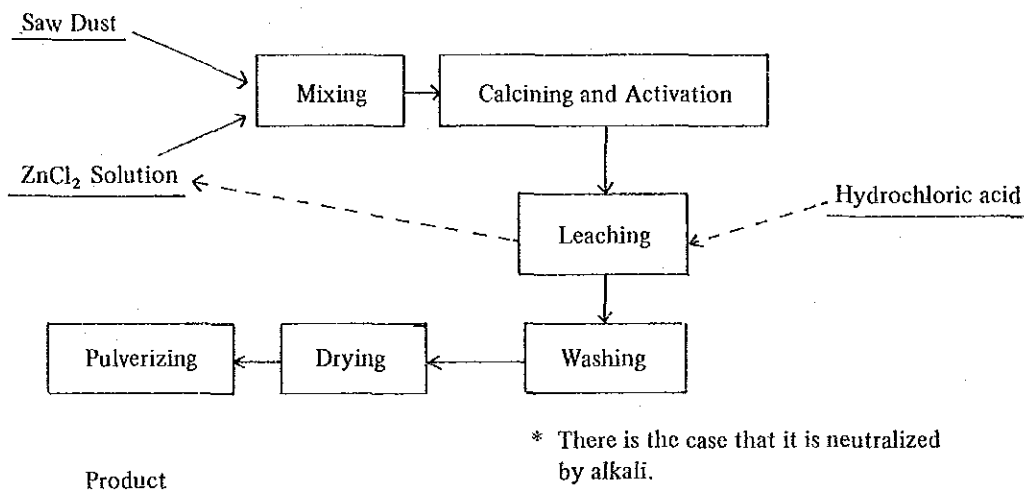
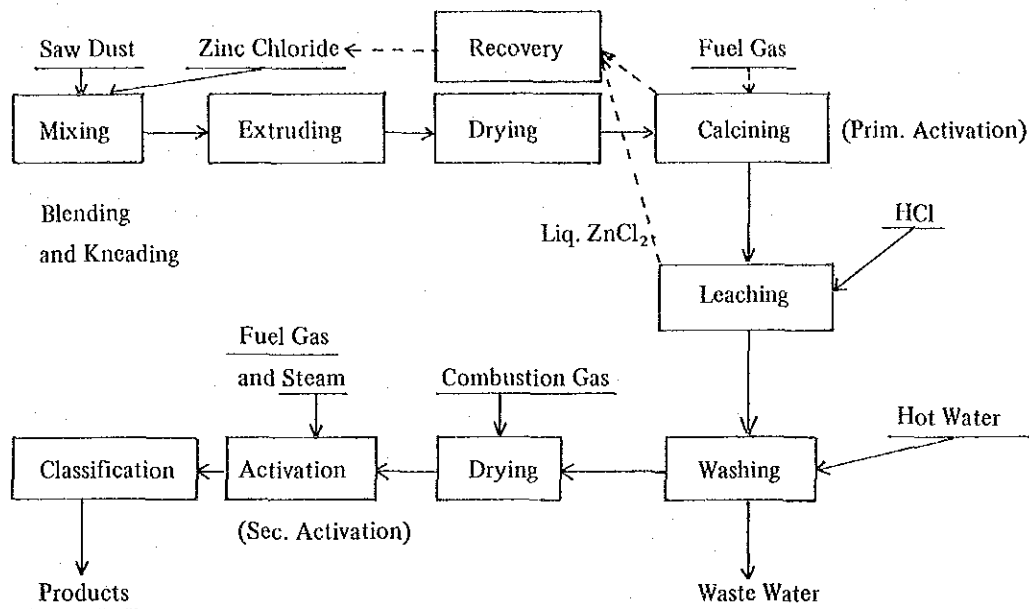


Table 2A-1-9 shows an example of unit consumption of raw material and power, and Fig. 2A-1-3 the process flow, for manufacturing granular activated carbon by the zinc chloride steam activation process.

Table 2A-1-9 UNIT CONSUMPTION OF RAW MATERIAL AND POWER FOR CHEMICAL ACTIVATION PROCESS

Sawdust (ton/ton)	3.0-3.2
Zinc chloride (ton/ton)	0.4-0.6
Electricity (kWh/ton)	300
Fuel gas (m <sup>3</sup> /ton)	2,000

Fig. 2A-1-3 GRANULAR ACTIVATED CARBON BY  $ZnCl_2$ -STEAM ACTIVATION



## 2) Gas Activation Process

In the gas activation process, carbonized raw material is reacted with carbon dioxide gas and steam at high temperature to generate a porous structure that increases the adsorbability of carbon substantially.

### i) Carbonization Process

Carbonized raw material is used in the gas activation process. The raw material (wood, sawdust, coconut shell, peat, lignite, coal, etc.) is first carbonized as obtained or after processing.

Carbonization temperature is  $350-600^{\circ}C$ . The raw material dried at  $100-150^{\circ}C$  is partially combusted with the air limited or shut off completely, or heated with high-temperature combustion gas. Thermal decomposition starts at about  $170^{\circ}C$ , and carbonization is terminated when tar generation stops at  $350-600^{\circ}C$ .

The residual volatile matter contained in the carbonized substance will depend on the temperature, the treatment time and method, and the specific gravity and strength of the char will depend on the reaction condition. The influence caused by heating speed will differ

with the specific kind of raw material. Char manufactured in fixed bed tends to have a higher specific gravity.

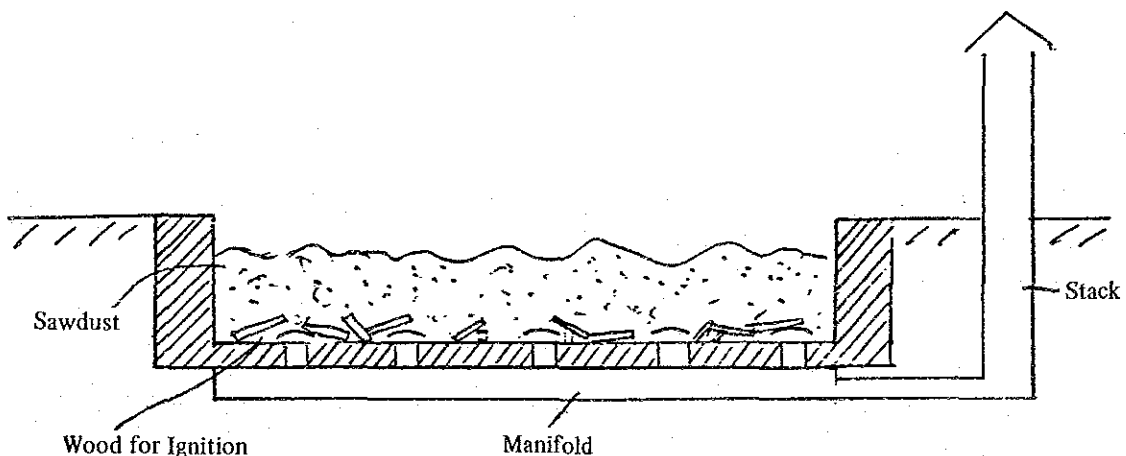
Raw material carbonized at a temperature of less than 600°C is regarded as providing raw material char that is more adapted to the gas activation process. But activated carbon can be produced even by carbonizing sugar at a temperature of 900°C, while carbonizing anthracite coal at 850–900°C in the presence of steam gives a porous char that lends itself to activation with ease.

Raw material of low ash content is more easily converted into activated carbon, but decoloration activated carbon can also be produced with ease by using a raw material containing an appropriate quantity of inorganic substances. A good example is the manufacture of bone char.

The specific kind and condition of existence of inorganic components have an effect on the activation reaction. Ash content dispersed finely in raw materials generally exerts an influence, while comparatively coarse ash content such as sand that is simply mixed hardly exerts any influence on the reaction. It rather has an effect of deteriorating the activated carbon's performance and therefore influences the activated carbon's adsorption capacity per unit weight.

A carbonation furnace shown in Fig. 2A-1-4 can be used for manufacturing char. In this case, waste wood is ignited in the furnace and sawdust is spreaded thinly on the firewood when it starts combusting. On the carbonized sawdust is successively spreaded additional sawdust. After carbonization is completed in a few days, water is sprayed to extinguish the fire and the char is taken out of the furnace.

Fig. 2A-1-4 CARBONIZATION FURNACE FOR WOOD CHAR MANUFACTURE



A fluidized bed carbonization furnace may be used. In this case, the carbonization is accomplished in several minutes, but while there is the advantage that product of uniform quality is obtained at a high efficiency, there is also the disadvantage that the facility is rather expensive. Regarding the product quality, char of slightly lighter substance is produced by the fluidized bed type carbonization.

Table 2A-1-10 shows an example of technical analysis of char.

**Table 2A-1-10 TECHNICAL ANALYSIS OF WOOD CHAR**

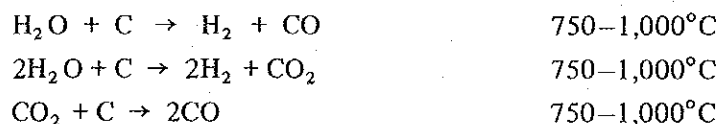
Fixed Carbon	60–80%
Moisture	5–10%
Ash	1–2%
Volatile Matter	15–30%
Bulk Density (Packed)	0.13–0.2 g/ml
Mesh	10–80 mesh

Raw materials other than sawdust are also usable for manufacturing char. For example, there was a process for obtaining activated carbon in which lignin obtained as residue in the process of wood saccharification is treated by fluidized bed carbonization and fluidized bed activation. It had been put to pilot plant test and demonstration test over a long period of time, and had been confirmed to have high potentials for commercialization.

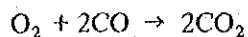
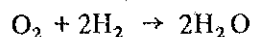
ii) Activation Process

a) General Description

Oxidizing gases which act on char of high temperature, such as air, steam and carbon dioxide react with char to remove carbon partially and promote the generation of fine pores by the following reactions:



Activation gas is generated by recombustion of combustible gas, as follows:



Partial combustion has the effect of combusting the char and of losing a part of it, but on the other hand it supplies the heat necessary for maintaining the required activation gas and activation temperature. The combustion speed of the combustible gas is faster than the combustion speed of char, but the actual combustion rates of both combustible gas and char are changed depending on the condition of their contact with air. Therefore, the properties and yield of activated carbon vary depending on the structure of activator and operating conditions.

As for the activation agent, steam is more effective than carbon dioxide under the same conditions. A comparison of the reaction speeds of these two activation agents has been announced recently with respect to coal char.

At higher temperature activation agents react fast, and even a slight temperature difference exerts a large influence on the production capacity.

The reaction temperature also has an effect on the quality of the product. That is, the iodine adsorbability or phenol adsorbability can be given over a wide range of temperatures, but the caramel decoloration capability, for example, will be generated only over a limited range of temperatures. In many cases, the range of optimum temperature will depend on the characteristics of the char.

The method of introducing air directly into the activation furnace will be advantageous in case the raw material char is inexpensive and the ash content also relatively low, since no fuel supply mechanism is required other than for the supply of raw material char. However, in case inexpensive gaseous or liquid fuel is available and the raw material char is comparatively expensive, the fuel together with air may be induced into the activation furnace, or high-temperature combustion gas may be introduced into the activation furnace after being burnt completely in pre-combustion room.

When using liquid fuel, caution will be necessary not to generate non-combusted tar, especially with the former method of direct introduction with air. In case of the latter method, operation control will be comparatively easy but since the heat loss from the walls of the pre-combustion room will be large. This problem will have to be solved through furnace design.



Fig. 2A-1-5 COMPARISON OF ACTIVATION PROCESSES

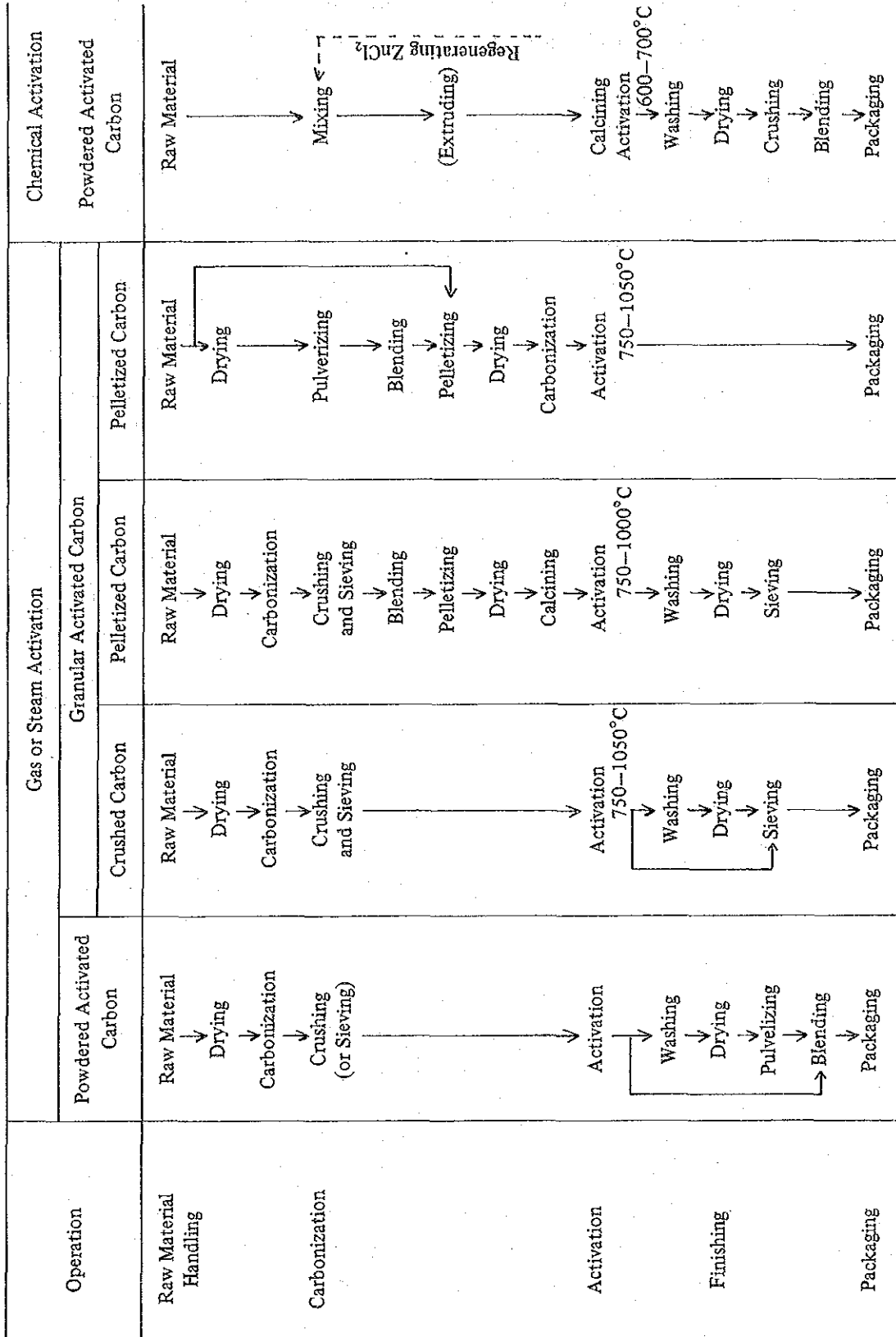


Fig. 2A-1-5 offers a comparison between a typical activated carbon manufacturing process and the chemical activation process.

b) Fluidized Bed Activation Process

In about 1910, F. Winkler applied the fluidized bed concept to the manufacture of activated carbon. This technology underwent development as a technology for the manufacture of synthesis gas and fuel gas by Winkler's coal gasifier, but failed to gain popular acceptance for the activation process for activated carbon.

Subsequently, the fluidized bed catalytic process developed in the fields of oil refining and eventually came to be utilized for the manufacture of activated carbon.

The fluidized bed process, properly utilized, enables manufacture of quality activated carbon at low costs.

In the furnace for activating char by the fluidized bed process, the activating gas is blown up from below a layer of carbon particles for activating the carbon particles in fluidized state, and the generated activated carbon is output from the furnace while being classified by the gas flow. There is also the method of accomplishing only char particle preheating by means of a fluidized bed, and activating the particles by a separate zone.

The advantages of the fluidized bed process are summarized as follows:

- (1) Temperature distribution in the fluidized bed is generally more uniform than that in the fixed bed, and it is also possible to maintain the temperature distribution non-uniform intentionally still retaining some regularity.
- (2) The same can be said in connection with material distribution (particle size distribution, volume distribution, etc.)
- (3) The heat transfer rate being large between particles and fluidized medium, inside the fluidized bed and between the fluidized bed and furnace walls, the fluidized bed is convenient for unit operation or reaction involving large heat evolution or absorption. In addition, the system can be designed with a large treatment capacity per unit volume.

- (4) Since pulverized substances can be handled, contact surface area is large, which has the effect of increasing the reaction rate and substance transfer speed and generally results in a large capacity. In treatments in which the surface area is not a rate-determining factor, the coarser the particle size, the system capacity becomes larger.
- (5) Feeding of raw material particle and discharge of product is as easy as that of liquid.
- (6) Owing to intense agitation, a stirrer is generally unnecessary excepting those cases when coagulating powders are used or when local overheating poses a problem.
- (7) Since operation is more stable than that of fixed bed, the system can be designed with a large capacity and system automation can be accomplished with ease.

The activation temperature will differ according to the specific kind of raw material char. The gas velocity in the furnace and handling capacity of char are set to suitable conditions depending on the particle size of the raw material char to be treated, though they are restricted by the heat balance necessary for maintaining the furnace at a required temperature.

From the standpoint of product quality, a furnace of large heat loss will be characterized by considerable partial combustion, and a high ash content of the product. Therefore, the furnace is liable to be operated with a longer residence time of char exceeding the point at which the product activated carbon's adsorbability attains its maximum value.

The fluidized bed system can be classified into several types according to the condition of contact between gas and the raw material's particles, feed and take-out methods, as described below:

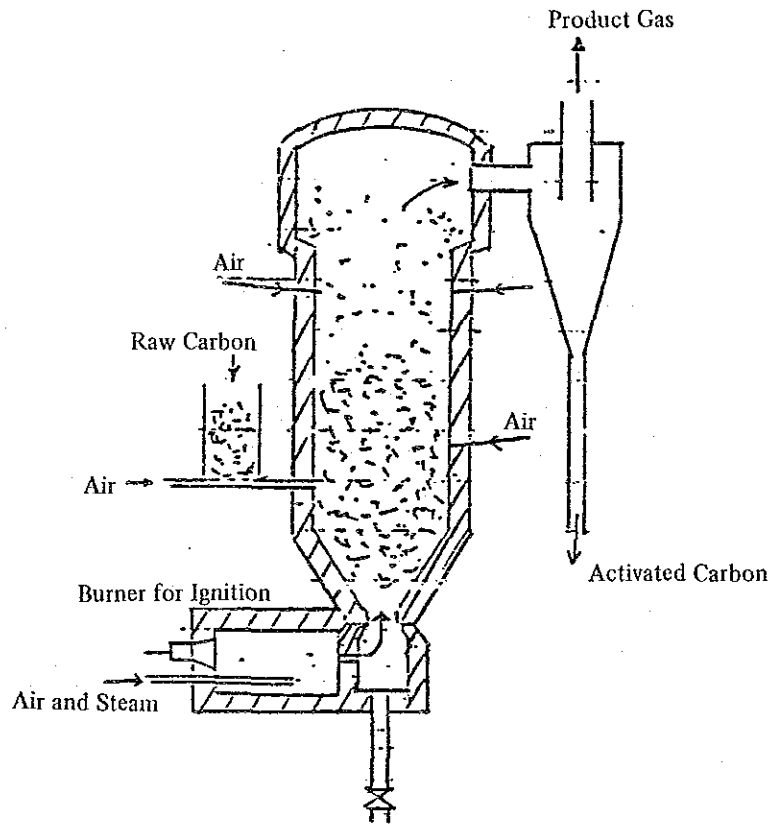
- (1) Single-Stage Continuous Fluidized Bed Activation Furnace

The product is blown off from exit of the furnace with flue gas. This operation utilizes the phenomena that the terminal velocity of the carbon becomes minimal after activation. Therefore, by utilizing this fact, the particles of

the activated carbon are classified by blowing them upwards.

Fig. 2A-1-6 shows a typical furnace of this type. Besides the one shown in this Fig. 2A-1-6, there is also a furnace, which has porous plate made of refractory for dispersion of gas.

**Fig. 2A-1-6 SINGLE-STAGE CONTINUOUS FLUIDIZED BED ACTIVATION FURNACE**

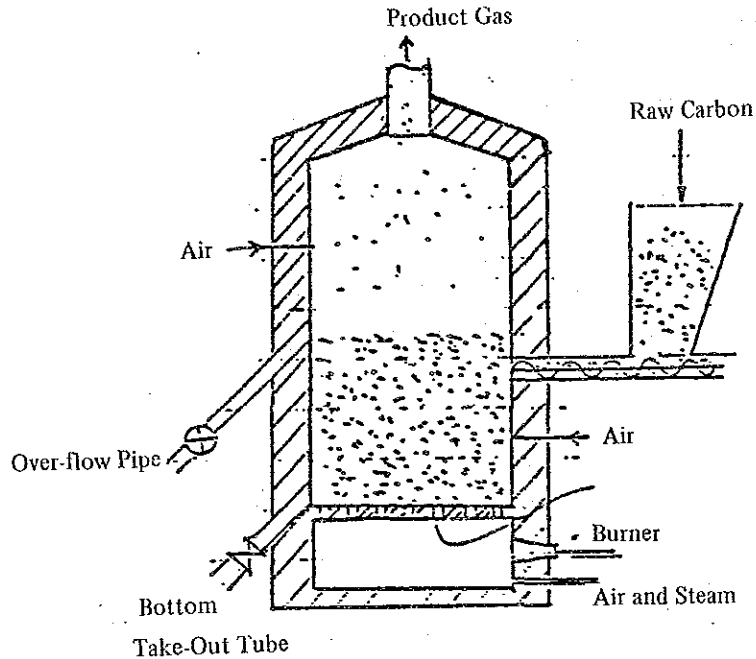


(2) Continuous Single Fluidized Bed Activation Furnace with Overflow Pipe

This system increases the ratio of raw carbon getting mixed in the product without being activated, so this system is regarded as impractical today.

(See Fig. 2A-1-7.)

Fig. 2A-1-7 CONTINUOUS SINGLE FLUIDIZED BED ACTIVATION FURNACE WITH OVERFLOW PIPE



(3) Batch Type Single Fluidized Bed Activation Furnace

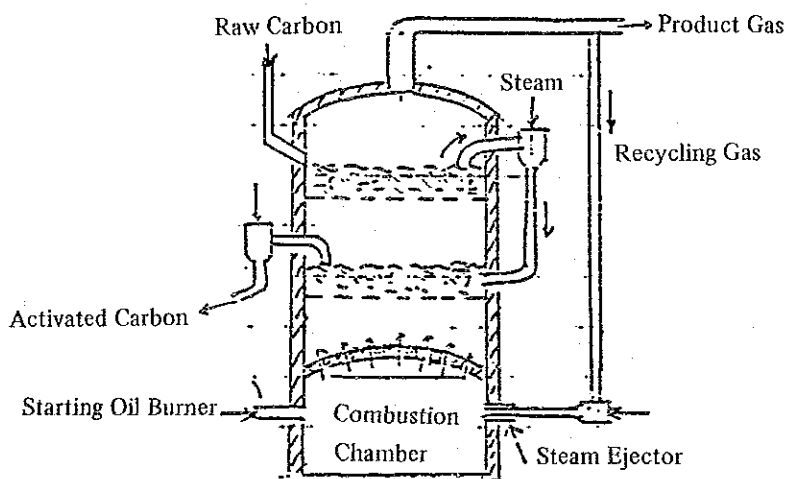
This system is essentially the same as the furnace described above, but is operated on the batch or semi-batch system. With the batch system, the raw material char is fed in batches and activated. The entire volume is taken out through the bottom take-out tube after completing of activation. The retention time being uniform, product of uniform quality is obtained. This furnace is suitable for the activation of granular char having a narrow range of particle size distribution. Auxiliary fuel has to be used.

On the other hand, with the semi-batch system, the raw material char is fed continuously or intermittently, and the overflow pipe is opened and closed regularly for product take-out. Differing from the batch type system operation is easier since there is only a slight temperature variation, and only a small volume of non-activated particles are mixed in the product.

(4) Continuous Counter-Flow Multi-Stage Fluidized Bed Furnace

Fig. 2A-1-8 shows an example of a 2-stage furnace. Preheating of raw material char and activation at a comparatively low temperature are achieved in the upper-stage fluidized bed, and the particles treated here are fed into the lower-stage fluidized bed. In the lower-stage fluidized bed, the particles are activated by the highly heated combustion waste gas sent from the combustion chamber, and the activated carbon generated here is taken out of the furnace by using a steam ejector. With this type of furnace, the use of an auxiliary fuel is a requisite. The exhaust gas is recovered for reutilization.

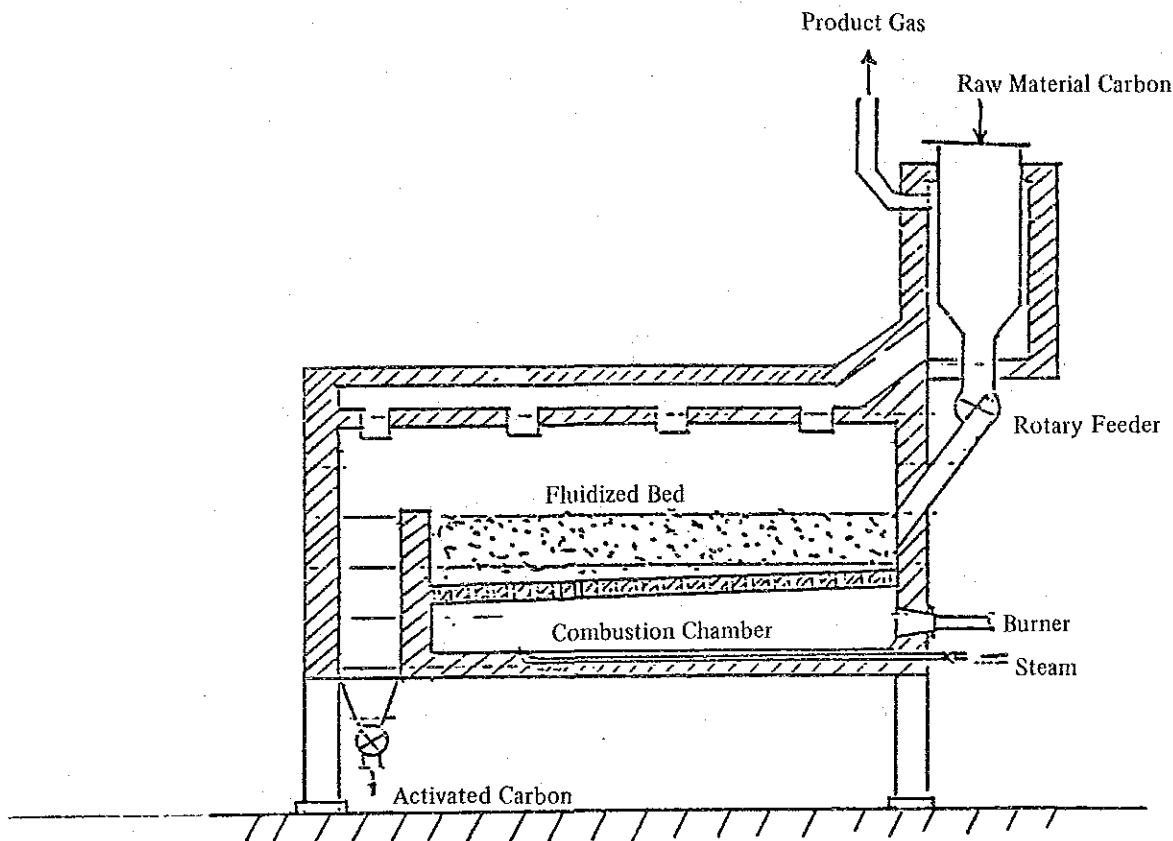
Fig. 2A-1-8 CONTINUOUS COUNTER-FLOW TWO-STAGE FLUIDIZED BED FURNACE



(5) Continuous Cross-Flow Fluidized Bed Furnace with Single Activation Chamber

In the case of a furnace of single chamber fluidized bed non-activated raw material particles come out mixed with the product. For this reason, continuous cross-flow fluidized bed furnace shown in Fig. 2A-1-9 has been proposed.

Fig. 2A-1-9 CONTINUOUS CROSS-FLOW FLUIDIZED FURNACE WITH SINGLE ACTIVATION CHAMBER (NORIT'S PAT.)



(6) Circular Fluidized Bed Furnace

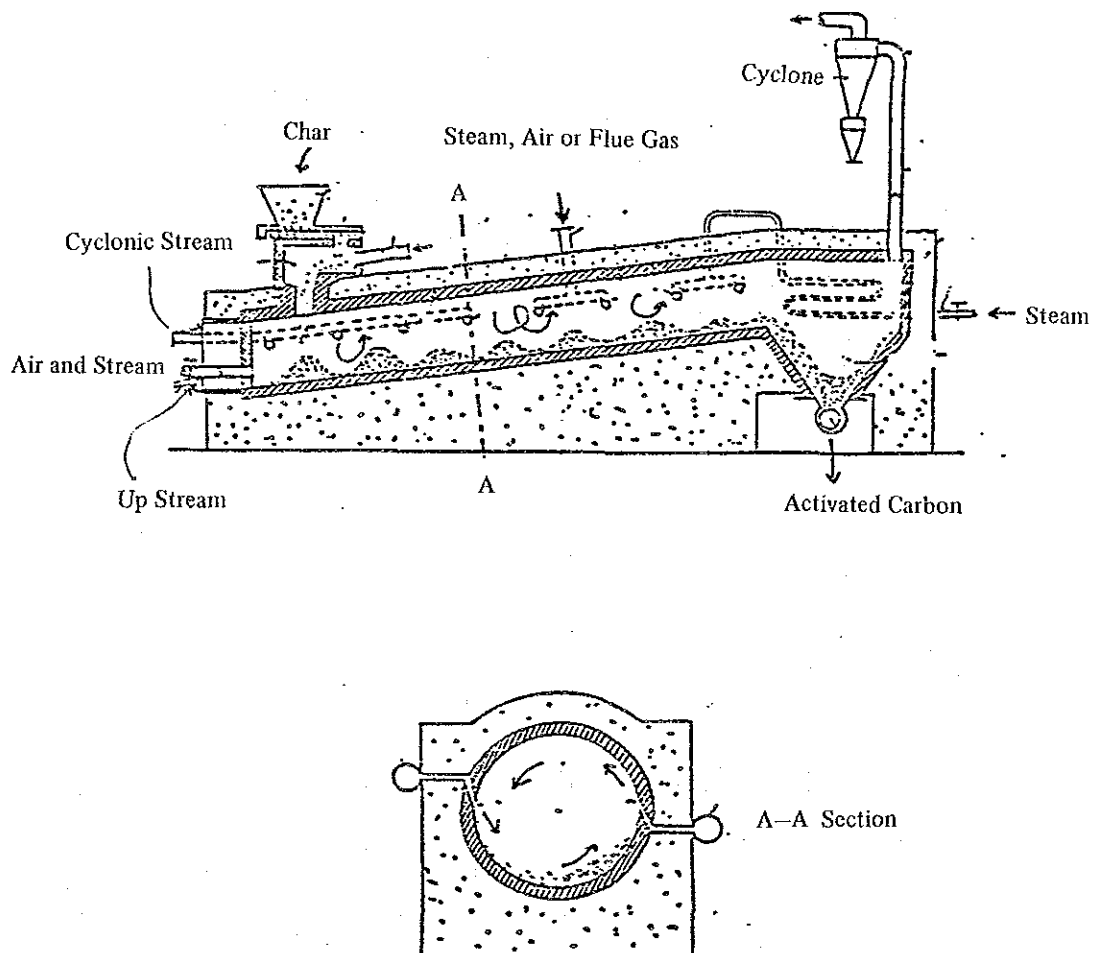
The fluidized bed features various advantages, as already described, but on the other hand it has a number of disadvantages, and the existing trend is for these disadvantages of the fluidized bed furnace to be eliminated while maintaining the advantage of the fluidized bed.

The circular fluidized bed furnace may be regarded as a modified cyclone furnace. While partly forming a fluidized bed and simultaneously utilizing the cyclone effect of its compartment, the circular fluidized bed furnace aims to separate non-activated particles and to extend the retention time in the compartment, and is highly suitable for the manufacture of powdered activated carbon. As contrasted with ordinary fluidized bed furnaces, there

is no need of fluidizing heavy non-activated particles at a high temperature, so it features minimal consumption of electricity for blowers and is also free of troubles associated with ash fusion.

Also, since the char particles in the upper space of the furnace are concentrated near the walls by action of centrifugal force, the generated gas can be burned separately. As a result, no auxiliary combustion chamber is required and its consumption of auxiliary fuel is also minimal. Fig. 2A-1-10 shows an example of this type of furnace. Depending on the structure of the furnace and its operating conditions, the furnace may lie closer to an ordinary fluidized bed furnace or closer to a cyclone furnace.

Fig. 2A-1-10 CIRCULAR FLUIDIZED BED FURNACE





c) Rotary Kiln Type Activation Process

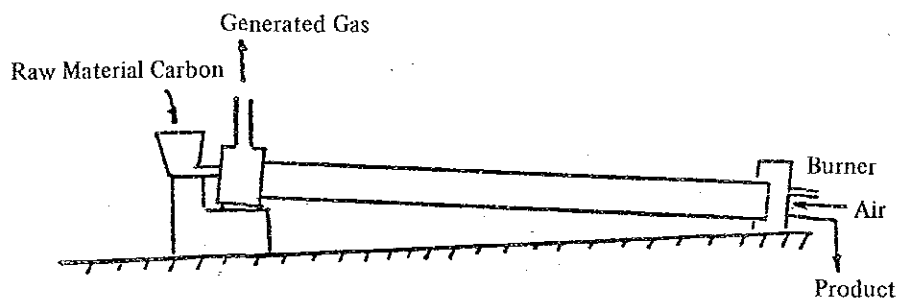
Differing from the use of a fluidized bed or fixed bed, the activation reaction in a rotary kiln is accomplished through mutual contact between the slowly moving bed surface and activation agent, also through contact of the descending char particles stirred up by blades and the flow of activation agent.

That is, the contact between the hot gas flow in the upper space of the kiln and the particle layer that moves forward while constantly changing its surface is the decisive factor in the activation reaction.

The oxidized gas is generated by combusting the fuel with almost theoretical air volume and blown into the kiln's upper space with or without steam. Depending on the condition of the upper space, excess air is supplied to combust the generated gas as a means of accelerating the activation reaction.

With a comparatively small kiln, the external heating method is also adopted. However, in this case the fuel consumption rate will be high, so various countermeasures are devised to lower the heat loss. Fig. 2A-1-11 shows an example of an internal heating type rotary kiln.

Fig. 2A-1-11 INTERNALLY HEATING TYPE ROTARY KILN



The rotary kiln not being limited by the raw material char's particle size or shape, it has a large flexibility in setting the activation temperature as well as the kind, quantity of the activation agent and retention time.

However, as compared with fluidized bed, its disadvantages are high investment and operation costs, and maintenance costs are also higher in general.

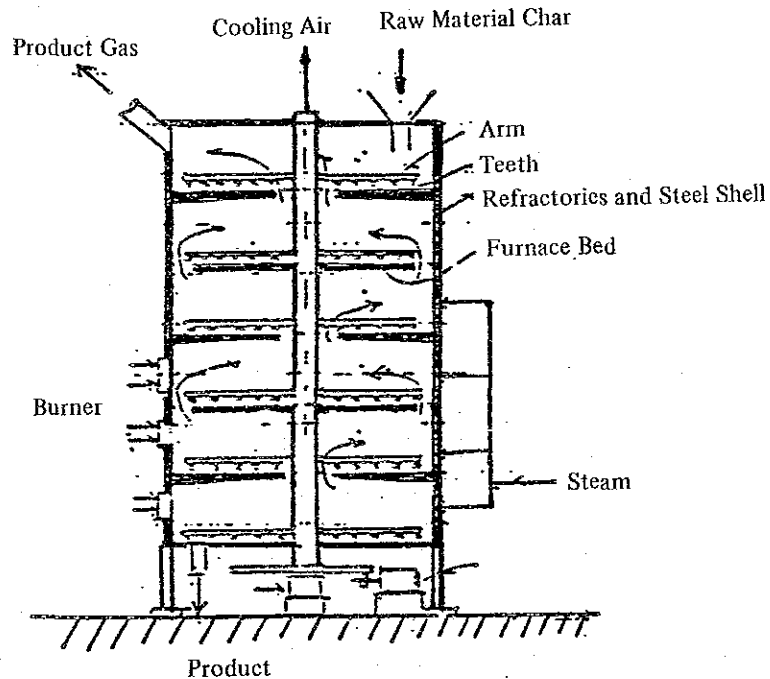
d) Activation by Multi-Hearth Furnace

The Herreshoff furnace that once used for sulfide ore roasting is also used as an activation furnace.

As compared with the rotary kiln, in this furnace the driving force for moving the raw material char forward are the stirring arms. The functions of these stirring arms are to spread the raw material evenly on each stage of furnace bed, forming a contact surface layer with the activation gas flowing in the upper space of the furnace, stirring and constantly creating new contact surfaces, and moving along the furnace bed in order to drop the char under treatment onto the lower-stage activation bed.

The activation gas flows from bottom stage to top stage, and both fuel and secondary air are supplied additionally in each stage in order to promote the activation reaction and to regulate the temperature. (Refer to Fig. 2A-1-12.)

Fig. 2A-1-12 HEARRESHOFF FURNACE



This furnace is also used popularly for the regeneration of spent granular activated carbon. However, when treating spent activated carbon generating corrosive gases, the stirring arms made of steel alloy are corroded so in such a case the fluidized bed furnace becomes more suitable.

A problem with the Herreshoff furnace is its high cost.

### 3) Manufacture of Molded Activated Carbon

Molded activated carbon is generally produced from some carbonaceous substance such as petroleum pitch or coal by the processes of molding, granulation, carbonization and activation.

Various molding processes are adopted, such as the briquetting, pelletizing, rolling, granulation, extrusion molding and drip molding processes. These processes are in commercial adoption today, with the specific process selected according to the properties of the raw material and the product's target properties (particle size, wear resistivity, density, etc.)

The thermal conditions (treatment temperature, time, heating method, etc.) involved in the carbonization treatment exert a large influence on the product's properties.

The product's adsorbability is increased as activation proceeds, but the yield, the strength and bulk density tend to be decreased, so when engaging in industrial manufacture due study should be given to optimum activation conditions.

#### i) Coal-Based Granular Activated Carbon

Coal is known to contain a large percentage of carbon and is a natural resources that is generally abundant and available at a moderate price.

However, coal differs widely in carbon content, ash content, viscosity and reactivity depending on the plant from which it is derived, the age of its generation and the natural conditions (geostatic, geothermal, biotic and other factors) that were involved in the process of its formation.

Also, coal are classified into the grades of lignite, sub-bituminous, bituminous and anthracite, but even with the same lignite coal, its properties will differ widely depending on whether it belongs to woody lignite or carbonaceous lignite. With woody lignite, the existence

of woody substance is detected even with the naked eye, and it is similar to wood from the aspect of activated carbon raw material. Meanwhile, carbonaceous lignite is brownish in color and no wooden matter is evident. It is generally powdered easily and contains much ash.

Raw material coal used in the industrial manufacture of granular activated carbon will necessarily have to be available in a stable supply and possess acceptable properties, among which its mechanical strength is the most vital. For this, bituminous coal having an appropriate level of caking capacity is required for use as the raw material. Some bituminous coal, after being treated by crushing, classifying and carbonization, can be converted readily into granular activated carbon by suitable activation.

Bituminous coal is used in the manufacture of molded activated carbon singly or with coal of other grades. Bituminous coal has a low internal surface area, but this problem can be solved appropriately by the activation process.

Molded granular activated carbon is employed primarily for water treatment and gas adsorption, and features selective adsorbability and high mechanical strength. When manufactured under optimum conditions it possesses sufficient wear resistivity for adsorption and regeneration by the fluidized bed process.

As shown in Fig. 2A-1-13, the manufacturing processes essentially consist of pelletizing, carbonization and steam activation, and stress is placed on obtaining quality product at high yield. In the granulation operation, it is necessary to produce granules of uniform size and high density. In the carbonization process based on the external heating method, quality product featuring excellent porosity is manufactured while avoiding agglomeration among granules.

The activation process is also allowed to base on the external heating method. The granules already having been given the required porosity in the carbonization process, the activation process serves as the finishing process to further improve the fine porous structure.

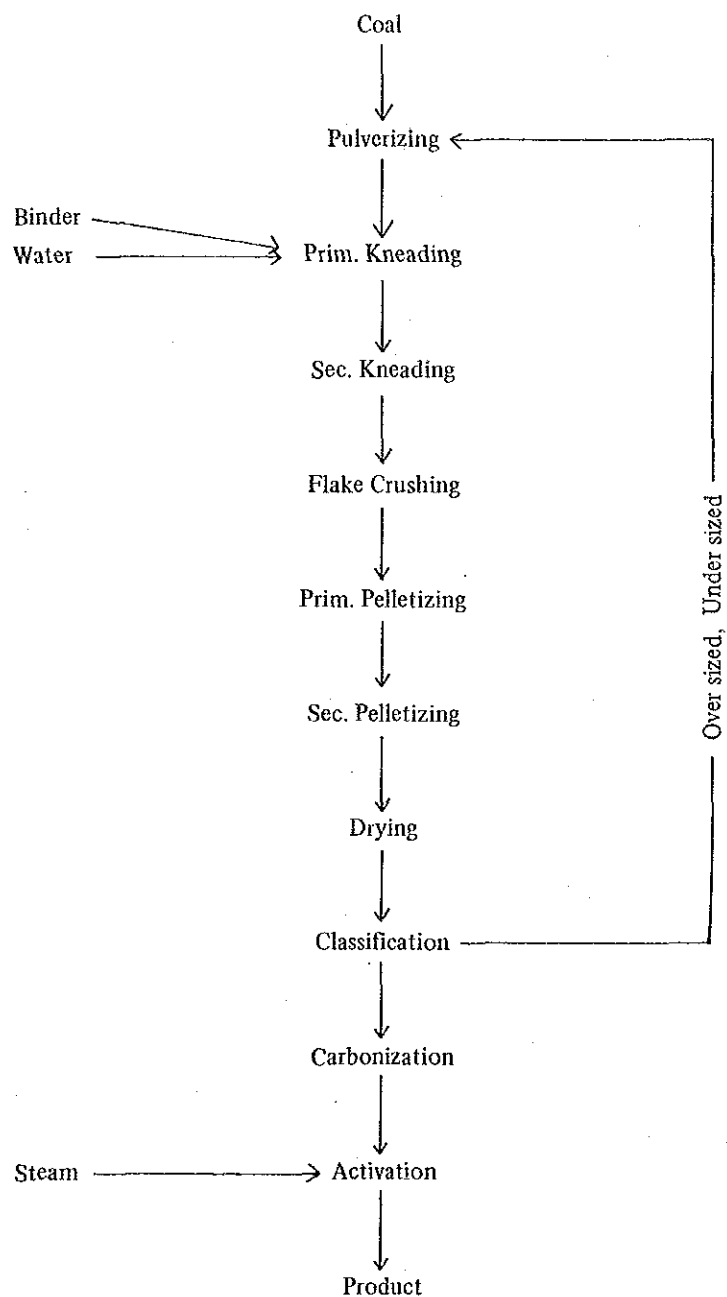
An example of basic conditions for this process is described hereunder.

a) Conditions for Granulation

(1) Pulverization of Coal

Pulverization has the effect of making the raw material homogeneous and of promoting the effect of addition of moisture and binders.

Fig. 2A-1-13 PROCESS FOR MANUFACTURE OF SPHERICAL ACTIVATED CARBON



(2) Granulating Moisture and Binders

Granulation is accomplished at room temperature. In the granulation process, the surface tension of the water promotes mutual coagulation of the pulverized particles, and pelletized products are produced by rotating the particles. The moisture plays a vital role in granulation, and is normally 10–15%. The granulation yield is as high as 90–95%. As for the binder, it has the effect of giving strength to the granulated carbon and promotes granulation. Binders such as pitch, pulp waste liquor, waste molasses and starch may be used.

(3) Granulation

The disc type granulating machine is suitable for granulation. Mechanical conditions are vital factors for manufacture of the granular carbon.

(4) Hot-Air Drying

Hard granular carbon is obtained by drying granules to a moisture content of 1–3% under mild conditions. A rotary dryer provides hard granules, and has the effect of increasing both hardness and bulk density by 10–15% compared with ordinary drying methods.

(5) Carbonization Conditions

Raw material bituminous coal is deficient of porosity. To obtain char for activation from bituminous coal it is necessary to remove gas and tar from the coal under pre-determined conditions, followed with the secondary operations of providing the char with open pores and the strength necessary for withstanding the activation process. For this, it will be necessary to select optimum conditions in connection with the temperature raising velocity, carbonization temperature, adjustment of caking property and carbonization atmosphere.

The carbonization temperature gives a large influence on mechanical strength. Coal loses its volatile matter as the heating temperature rises steadily and becomes amorphous carbon, after which it converts into a carbonaceous substance having a fixed crystalline structure while generating fine crystals.

The optimum temperature for obtaining great adsorbability and strength will vary with the kind of coal. In general, the optimum temperature for acquiring excellent adsorbability and that for acquiring great strength are not the same, so the optimum temperature will have to be selected with the thought of striking a balance between the two.

Table 2A-1-11 shows an example of the results of carbonization of granular carbon with a rotary kiln. Both pore volume and specific area attain their peak values at a temperature of 600°C. Meanwhile, the strength increases in proportion to the rise in carbonization temperature. Table 2A-1-12 shows an example of the results of carbonization at a temperature of 600°C.

#### (6) Conditions for Steam Activation

Activated carbon having suitable pore diameter and pore diameter distribution matched to its specific target application is manufactured by combining the activation temperature, steam quantity and period of activation time rationally.

#### ii) Petroleum-Based Granular Activated Carbon

Obtained in spherical shape, the petroleum-based granular activated carbon is otherwise known as the bead activated carbon. As compared with its coal-based activated carbon, it is obtained as a product having smaller particle diameter, and features excellent water resistivity and wear resistivity.

Fig. 2A-1-14 shows its manufacturing flowsheet.

## 2.4 Applications of Activated Carbon

### 2.4.1 General Description

Activated carbon is utilized widely in the fields of purifying of foods and improvement of their flavor, in the fields of manufacture of medical drugs, gas masks, catalysts, stabilizers and diverse commodities. As a recent trend, activated carbon has come to be used in increasing volumes for the preservation of good living environments, or specifically for decomposing and removing toxic substances, water pollution substances and foul odors which are formed

**Table 2A-1-11 INFLUENCE OF CARBONIZATION TEMPERATURE  
ON COAL-BASED CHAR PROPERTIES**

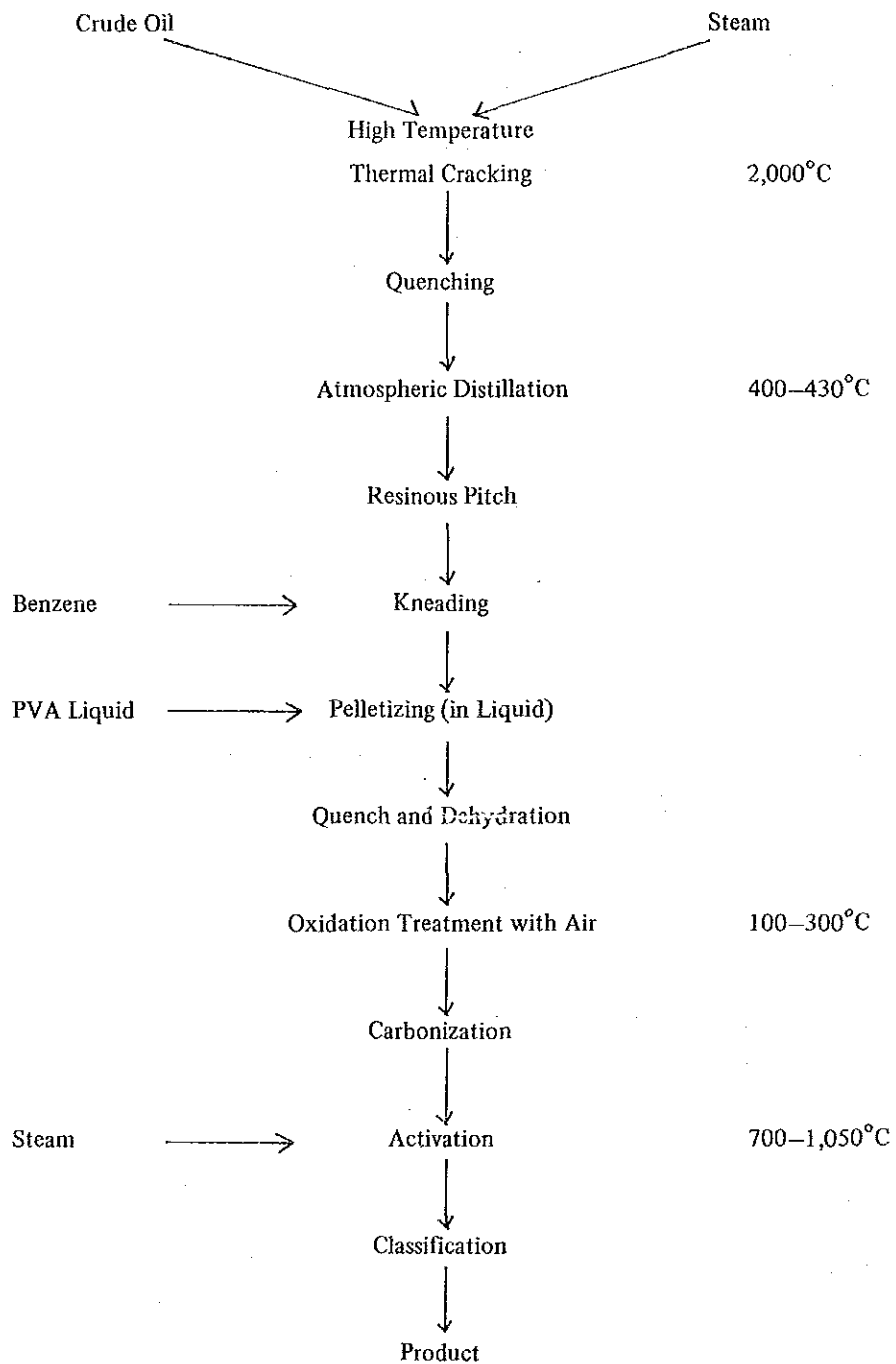
Carbonization Temperature	Pore Volume 75-75,000 Å ml/g	Specific Area m <sup>2</sup> /g	Micro Strength -
450	0.145	100	65
500	0.150	150	85
600	0.170	220	94
700	0.154	155	96
800	0.127	140	98
900	0.125	100	99
1,000	0.020	20	100

**Table 2A-1-12 RESULTS OF CARBONIZATION TESTS WITH VARIOUS  
TYPES OF FURNACES FOR COAL**

	Chamber Furnace	Internally Heated Rotary Kiln	Externally Heated Rotary Kiln	Fluidized Bed Furnace
Yield (%)	70	62	75	72
Apparent Specific Gravity (-)	-	0.96	1.13	1.127
Real Density (%)	-	1.90	1.54	-
Porosity (%)	-	49.5	26.7	-
Bulk Density (kg/l)	0.560	0.592	0.730	
Micro Strength (-)	80	89.5	99.5	92.5



Fig. 2A-1-14 FLOWSHEET FOR MANUFACTURE OF BEAD ACTIVATED CARBON FROM PETROLEUM PITCH



through our living, manufacturing and other social activities.

The adsorbability of activated carbon broadly classified, is put to the following four fields of application:

i) Refining

Refining is the operation of adsorbing and removing unnecessary components contained in relatively small quantities in commercial products by means of activated carbon in order to improve the values of these products. Activated carbon is used in combination with other agents and methods such as ion exchange resins and ion exchange membrane as a means of increasing the refining effect.

ii) Collection or Recovery

Valuable substances are adsorbed from mixtures consisting of numerous substances, followed with their separation and concentration for recovery.

iii) Fractionation

In this operation, the activated carbon's different adsorbability with respect to various foreign substances is utilized to separate a given product into two or more fractions in order to raise the value of the respective fractions.

iv) Other Applications

Activated carbon may also be used for slowly releasing the effects of adsorbed chemicals by utilizing its retention power. Its adsorbability and large inner surface area are utilized as a catalyst carrier. The activated carbon itself may also be used as a catalyst.

In practice, it will be difficult to clearly discriminate to which specific field of application the activated carbon is being put. For example, when treating air with activated carbon, the purpose of application is regarded as belonging to category (i) if the adsorbed substance is worthless, but (ii) if the adsorbed substance is a valuable substance such as a solvent. Also, if the operation is accomplished on a small scale, the cost for recovering and reutilizing the adsorbed substance will be high and uneconomical, so it will belong to category (i). But when accomplished on a large scale to make the recovery and reutilization payable, then the operation is regarded as belonging to category (ii). In this manner, the categories described above

are not absolute and are also determined by the economic effect that is involved.

Table 2A-1-13 shows the principal applications of activated carbon.

**Table 2A-1-13 PRINCIPAL APPLICATIONS OF ACTIVATED CARBON**

Water treatment	Dechlorination of service water; adsorption and removal of detergents, phenol, coloring matter, and organic substances from water; deodorization and removal of organic substances from service water; filtration of soft-drink water, fermentation water and potable water; pretreatment of industrial water, boiler water and raw water for water purification equipment; removal of mercury from waste water; treatment of industrial waste water and sewerage water.
Gaseous-phase adsorption	Air purification; refining gases in chemical industry; removal of oily odor from compressed industrial air; use in gas masks; removal of foul odors from refrigerators, jars and automobiles; removal of toxic and foul gases evolved in various kinds of chemical plants; adsorption and removal of toxic and foul gases at sewerage water treatment plants; adsorption and removal of radioactive substances; preservation of vegetable and fruit freshness, etc.
Liquid-phase adsorption	Refining of intermediates in petrochemical, synthetic resin and synthetic fiber industries; refining of by-product hydrochloric acid; decoloration, deodorization and purification in food processing industry; refining of medicine, chemicals and organic solvents; recovery of iodine; recovery of rare metals from waste solutions, refining of plating solutions, etc.
Liquid-phase decoloration and refining	Decoloration, deodorization and refining of industrial products, medicine and intermediate products; decoloration, deodorization and refining of sugar, glucose, fructose and monosodium glutamate; decoloration, deodorization and refining of amino acids and soy sauce, decoloration of sake; decoloration, deodorization and removal of organic substances from industrial waste water; decoloration of cleaning solvents, etc.

Adsorption of solvents	Adsorption and removal of organic solvent gases evolved in various industrial plants; recovery of solvents used in the manufacture of viscose acetate and photo-films; recovery of solvents used in printing, rubber manufacturing and painting plants; removal of carbon disulfide and hydrogen sulfide in rayon plants, etc.
Desulfurization	Adsorption and removal of sulfur dioxide gas and hydrogen sulfide gas contained in fuel oil combustion flue gases; adsorption and removal of sulfur dioxide gas, hydrogen sulfide gas and nitrogen oxides discharged into the atmosphere by various kinds of industrial plants; adsorption and removal of other kinds of toxic gases as well as foul gases evolved in sewerage water treatment and other facilities; use in air purification filters used for removing sulfur dioxide gas, hydrogen sulfide gas and other harmful gases, etc.
Adsorption of dilute gases	Adsorption of dilute radioactive gases such as krypton and xenon gases, adsorption of vinyl chloride monomers, adsorption and removal of mercaptan and other dilute foul gases, etc.
Use as catalyst and catalyst carrier	Use as a catalyst or catalyst carrier in fixed bed and fluidized bed type reactor for the synthesis of vinyl chloride, vinyl acetate, cyanuric chloride and phosgene.

Activated carbon is put to a very wide range of applications as shown in Table 2A-1-13, from water treatment to air purification, refining of sugar, seasonings, medicine and various other products, refining of sake and other alcoholic beverages, recovery of solvents, utilization in analysis, and use as a catalyst and catalyst carrier.

According to recent statistics in Japan, the principal uses of powdered activated carbon are for the refining of chemicals and solvents (28%), refining of sugar and fructose (15.3%), fermentation and seasoning refining (24.1%), water treatment (12.1%), refining of medicine (6.6%) and refining of edible oils (2.6%).

Meanwhile, granular activated carbon is being used predominantly for water treatment and for gas adsorption, with water treatment accounting for 40.9%, gas adsorption accounting for 39% (for air purification in industrial plants, buildings, etc.) and solvent recovery accounting for 4.9%, respectively, of the total volume of granular activated carbon that is being consumed

today. Incidentally, these are the fields of application in which the demand for granular activated carbon increased rapidly in recent years.

Switchover from powdered activated carbon to granular activated carbon is being promoted by such factors as the ease of handling of granular activated carbon, the establishment of technologies for regeneration and reutilization, absence of problems in the disposal of spent activated carbon and availability at about the same price level. The use of granular activated carbon requires a higher initial capital investment owing to the need of providing hold-up, but the system running cost is lower owing to the automation and continuous operations, so switchover to the use of granular activated carbon was made in fields where switchover was technically possible.

As for the existing trend of new applications for activated carbon in Japan, there is for example the removal of trihalomethanes and organic halogen compounds in the field of water treatment. Either powdered or granular activated carbon is usable for treating city water, and the primary purposes have hitherto been to remove foul odors including musty smell from city water. Therefore, a fixed demand for activated carbon can be expected from this field of application in view of the present situation of ever increasing contamination and nutrient enrichment of city water sources. However, a new demand appears likely for the use of activated carbon henceforth for removing trihalomethanes and/or for preventing their formation.

Trihalomethanes are formed when humic acid contained in city water sources react with chlorine that is added in the water for sterilization. Activated carbon used for preliminary treatment can adsorb humic acid preventing trihalomethanes to be formed. On the other hand, its use for after-treatment will permit adsorption of formed trihalomethanes.

Use of activated carbon is also effective for adsorbing and removing organic halogen compounds such as trichloroethylene which exist as pollutants in underground water.

Addition of powdered activated carbon into an activated sludge treatment tank for waste water is reported to have the effect of decreasing the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) to levels comparable to those attained through tertiary treatment (activated carbon adsorption treatment). This new technology enables existing activated sludge pondages to be utilized without constructing any granular activated carbon filtration column, thereby enabling huge capital investment funds to be saved, together with the advantage that no adverse influences are exerted even on the incineration of generated sludge.

This technology was put to commercial application in Kita-Kyushu City in Japan.

It is necessary to accomplish sewerage water treatment, more exhaustively as a means of preventing river and lake water from contamination, but there are many local governmental entities which have no surplus financial capabilities for constructing new water treatment facilities. Such being the case, it is probable that the above-mentioned technology becomes popular for treating sewerage water.

While coal-based activated carbon is being used predominantly for treating industrial waste water, coconut shell activated carbon has come to be used more popularly for water purification. In general, however, coal-based activated carbon excels in both adsorption capability and velocity owing to its larger number of transitional pores.

Activated carbon is also used popularly in automobile canisters (gasoline vaporization prevention device). That is, about 600 grams of activated carbon is used in each canister for export passenger cars (1,300 c.c. class) and about 150 grams for domestic cars, in which sector coal-based activated carbon accounts for 60–70% of the total share and runs up to a consumption volume of about 1,800 T/Y.

Nuclear power plants also consume activated carbon for removing radioactive gases and iodine, with each station consuming about 30–80 T/Y for radioactive gas removal and several tons for iodine removal (both for initial charge).

A significant event was the recent export of granular activated carbon to the Middle East for use in the preliminary treatment of feed water for a seawater desalination plant, specifically for removing oil and other impurities from sea water. Since the initial charge for this purpose is roughly 800 tons, annual make up of several dozen T/Y is anticipated for granular activated carbon in this sector.

#### **2.4.2 Refining in Food Processing Industry**

The use of activated carbon in the food processing industry has a long history. Table 2A-1-14 shows typical examples of activated carbon applications in this industry. Decoloration is by far the most predominating purpose, but in the fermentation industry, activated carbon has long been used for improving the flavor of stale alcoholic beverages.

When treating these various kinds of foods, their tint, aroma and flavor are generally conditioned by giving due study to the specific kind and volume of activated carbon to be used, also to the conditions of treatment.

Table 2A-1-14 LIQUID-PHASE REFINING IN FOOD PROCESSING INDUSTRY

Industry	Product	Operation and Improving Effect				Others
		Decoloration	Removal of Colloid	Crystallinity	Product Stabilization	
Sugar	Cane Sugar	o	o	o	o	Reuse, Recovery of Betaine, M.S.G.
	Beat Sugar	o	o	o		
	Molasses	o	o	o	o	
Starch	Glucose, Starch Syrup	o	o	o	o	Deodorization
Lactose	Lactose	o	o	o		"
Fermentation	Sake	o				Flavor and Taste
	Beer	o				"
	Wine	o				"
	Whisky, Rum, Brandy					"
	Vodka, Spirit					"
	Fruits Wine	o				"
	Shoyu (Soy Sauce)	o				"
	Vinegar					"
	Edible oil and Fats	Vegetable Oil	o	o		Deodorization
Margarine		o				"
Cacao Fats		o				"
Lard		o				"
Food Additive	Mono Sodium Glutamate	o	o		o	Deodorization
	Nucleic Acid-based	o	o		o	"
	Seasonings					"
	Seasoning Liquids	o		Flavor and Taste		"
	Lactic Acid, Citric Acid	o	o		o	"
	Tartaric Acid, Gluconic Acid	o	o		o	"
	Ascorbic Acid	o	o		o	"
	Agar-agar	o				"
	Pectin	o				"
	Gelatin	o				"
Miscellaneous	Syrup	o	o			"
	Fruits Juice	o	o			"
General	Candy	o		Reuse		"
	Various Kinds of Treating Liquids	o	o	Reuse		"
	Water Treating	o				"

a) Sugar Refining Industry

In the sugar refining industry, there is the process of filtration of unrefined sugar syrup for clarification and the decoloration process. The clarifying filtration process may consist of the carbonic acid clarification process or the phosphoric acid clarification process, which is followed with filtration and further with decoloration by the activated carbon process, bone char process or ion exchange process. This sugar syrup is then evaporated and concentrated into crystals which are separated as refined sugar from the mother liquor. The manufacturing process is shown in Fig. 2A-1-15.

Conspicuous improvements have been made in recent years in the refining process. This might be caused by the stringent request placed on the reduction of refining costs on one hand, and on the other hand, by strict specifications of quality of sugar used for soft drinks from the standpoint of heavy metal and ash contents as well as inhibition of solid substance precipitation. As a result, the combined use of granular activated carbon, bone char and ion exchange resins has come to be adopted predominantly. However, powdered activated carbon is also being used.

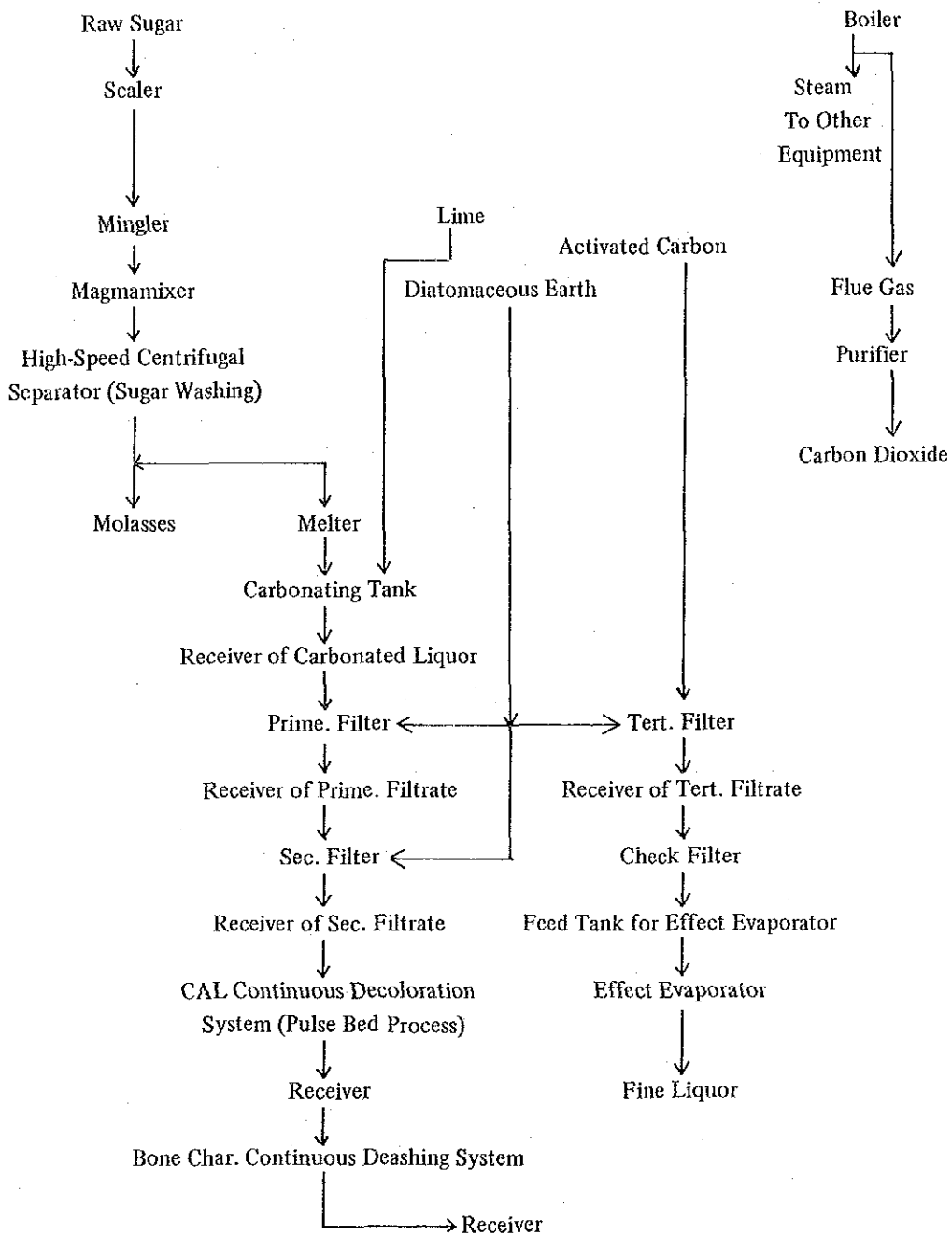
Granular activated carbon is used by the fixed bed process or the pulse bed process. The latter had been attended with the problem of generation of pulverized particles owing to the abrasion of activated carbon, but the problem has been solved through process improvement. Also, granular activated carbon is attended with the problem of effusion of impurities, and in this aspect, it is inferior to the powdered activated carbon.

Powdered activated carbon, when used in cane sugar refining, displays various advantages as an adsorbent. For example, it displays excellent decoloration effect within a short period of contact with sugar syrup and provides clear sugar syrup by adsorbing not only the coloring matter existing in the syrup but colloids and inorganic substances as well. Powdered activated carbon displays superlative clarification effect especially when sugar syrup is treated by the phosphoric acid process.

Sugar syrup discharged from the granular activated carbon-packed column or bone char-packed column frequently lacks the desired clarity, in which case powdered activated carbon is employed for after-treatment by adding it to the extent of 0.1—0.4% with respect to the solid sugar content.



Fig. 2A-1-15 EXAMPLE OF PURIFICATION AND DECOLORATION OF SUGAR



When converting from the bone char-packed column to the activated carbon process, the latter process will involve the use of activated carbon in combination with an ion exchange resin-packed column. This is because bone char inherently has an ion exchange effect with respect to sugar syrup, which happens to be one of the reasons why the bone char process is being adopted even today.

In a large-scale sugar refinery, a sugar refining process using powdered activated carbon predominantly is regarded as being disadvantageous compared with the use of granular activated carbon since its regeneration process has not yet been established. However, should it become possible to regenerate spent activated carbon, the intrinsic merits of powdered activated carbon may be reassessed.

b) **Sodium Glutamate Industry**

The discovery that the taste component of sea tangle comes from L-glutamic acid by Dr. Kikunae Ikeda in 1908 eventually led to the establishment of the L-glutamic acid industry for producing the seasoning substance.

In the initial stage, the seasoning was produced by hydrolysis of wheat gluten with hydrochloric acid, followed with refining and obtaining sodium glutamate in the form of a crystal. It was marketed under the trademark of "Ajinomoto." Subsequently, the discovery by Dr. Shukuo Kinoshita in 1957 that it can be produced from glucose and ammoniacal nitrogen by the fermentation process led to the manufacture of the substance by using molasses as a raw material.

Specifically, L-glutamic acid is crystallized and separated from a fermentation liquor, neutralized with sodium hydroxide, followed with decoloration of the solution with powdered and granular activated carbon, then sent to the final crystalline product precipitation process.

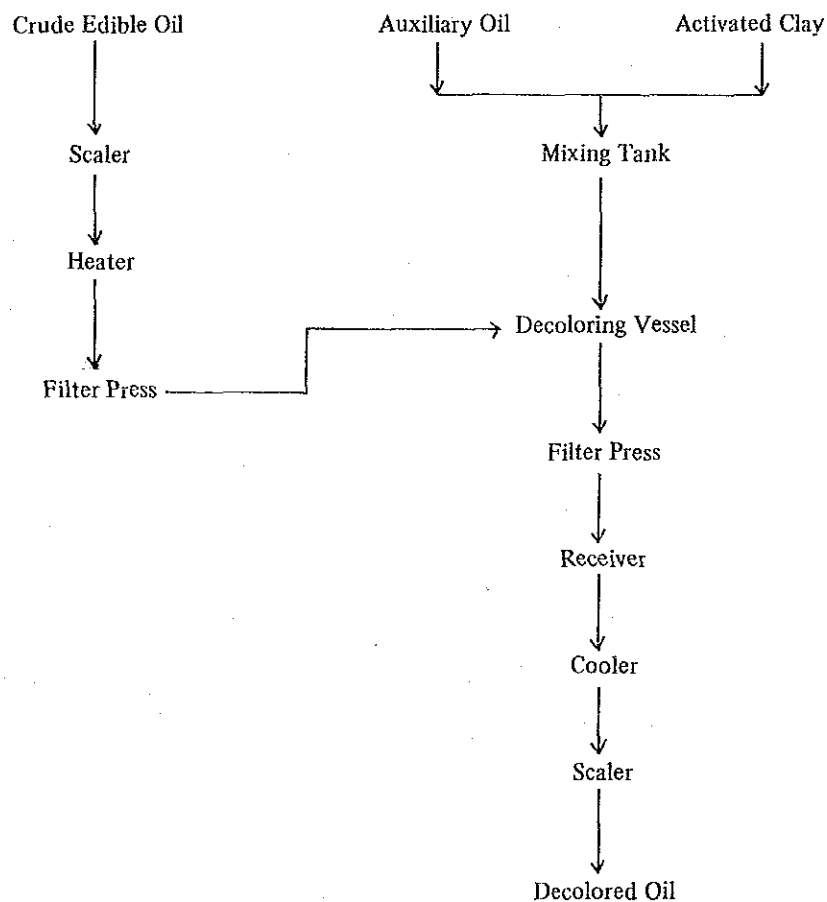
The L-glutamic acid of 95–98% in purity is separated from the fermentation liquor in the form of a coarse crystal that contains impurities including nitrogenous compounds such as coloring matter, amino acids and proteins, also inorganic salts, which exist in the form of mother liquor adhesives and substances adsorbed in the crystal.

The coloring matter is a mixture of coloring matter, such as melanoizine coloring matter or caramel contained in molasses, coloring matter formed by bacteria in the fermentation process, and brownish coloring matter generated together with

insoluble humine substance in the hydrochloric acid treatment process. Since both glutamic acid and coloring matter display very similar dissolving characteristics, there is a great possibility of the larger portion of the coloring matter to be contained in glutamic acid crystals.

Decoloration of solutions consisting of coarse sodium glutamate crystals is accomplished by the independent or combined use of adsorbents such as powdered activated carbon, granular activated carbon, non ionic decoloration resin and anion exchange resin.

Fig. 2A-1-16 CONTINUOUS VACUUM DECOLORATION SYSTEM FOR OIL AND FAT



c) Refining of Edible Oils & Fats

In the edible oils and fats industry, activated carbon is used together with activated clay for refining. Crude oils and fats contain natural coloring matter, odors and free fatty acids such as naturally existing carotene, xanthophyl and chlorophyll.

Depending on the specific type of vegetable oil, the ratio of the activated carbon and activated clay used for refining, as well as the treatment temperature and period of contact time, will be varied, as shown in Table 2A-1-15.

Fig. 2A-1-16 shows a closed type continuous vacuum decoloration system.

d) Application to Sake Brewing

In the initial stage of import of activated carbon into Japan, it was used for the purpose of improving the flavor of so-called inferior and stale sake, but later it became common to use activated carbon for the decoloration and flavor adjustment of sake.

Today, sake is being treated with activated carbon after consummation of brewing and before shipment with the purpose of suppressing its coloration and over-aging during storage, decoloration before shipment, flavor conditioning, and inhibition of staling and coloration after shipment, or for the preservation of sake from the stage of its brewing to its final delivery to end consumers.

The color of sake is generally classified into ferrichrome-based coloring matter, flavin-based coloring matter and melanoizine-based coloring matter. Activated carbon is primarily used to remove melanoizine-based color.

Sake is known to take on disagreeable odors and flavors due to various causes, and if activated carbon is used for its treatment, a large quantity will have to be used and even the distinct, natural flavor of sake is lost. In such a case, use of carbon molecular sieves (CMS) provides good results. Table 2A-1-16 shows the results of related research.

Sake is also refined by using granular activated carbon. The spent granular activated carbon is regenerated by passing a sodium hydroxide solution heated to 80–90°C through an adsorption column. In order to attain the same decoloration effect,

**Table 2A-1-15 CONDITIONS FOR DECOLORATION OF EDIBLE OIL AND FAT**

	Mixing Ratio		Decoloration Temperature
	Activated Clay	Activated Carbon	
Refined Coconuts Oil, Palm Oil	70 – 75 %	30 – 25 %	90 °C
Crude Coconuts Oil, Palm Oil	80 – 85	20 – 15	90
Animal Fat (Oxen Fat, Lard)	85 – 90	15 – 10	90 – 95
Refined Cotton Seed Oil	92.5	7.5	95
Refined Corn Oil	92.5	7.5	95
Refined Rape-Seed Oil	90	10	100 – 110
Refined Peanuts Oil	90 – 95	10 – 5	75
Linseed Oil	95	5	110 – 120
Caster Bean Oil	90 – 95	10 – 5	80

**Table 2A-1-16 COMPARISON OF SAKE DECOLORATION CAPABILITY OF CARBON MOLECULAR SIEVES AND GENERAL ACTIVATED CARBON**

Added Carbon			Carbon Decoloration Capability	
			Powdered CMS	Powdered Activated Carbon
Raw Sake No. 1 (Fresh)	0.05 %	10.5 %	61.5 %	
Raw Sake No. 1 (Fresh)	0.25	12.5	68.0	
Raw Sake No. 2 (Old)	0.2	4.0	56.5	
Raw Sake No. 3 (Old)	0.3	21.0	70.0	
Raw Sake No. 4 (Old)	0.5	16.0	66.5	

Fig. 2A-1-17 PROCESS FOR MANUFACTURING GLUCOSE BY ENZYME

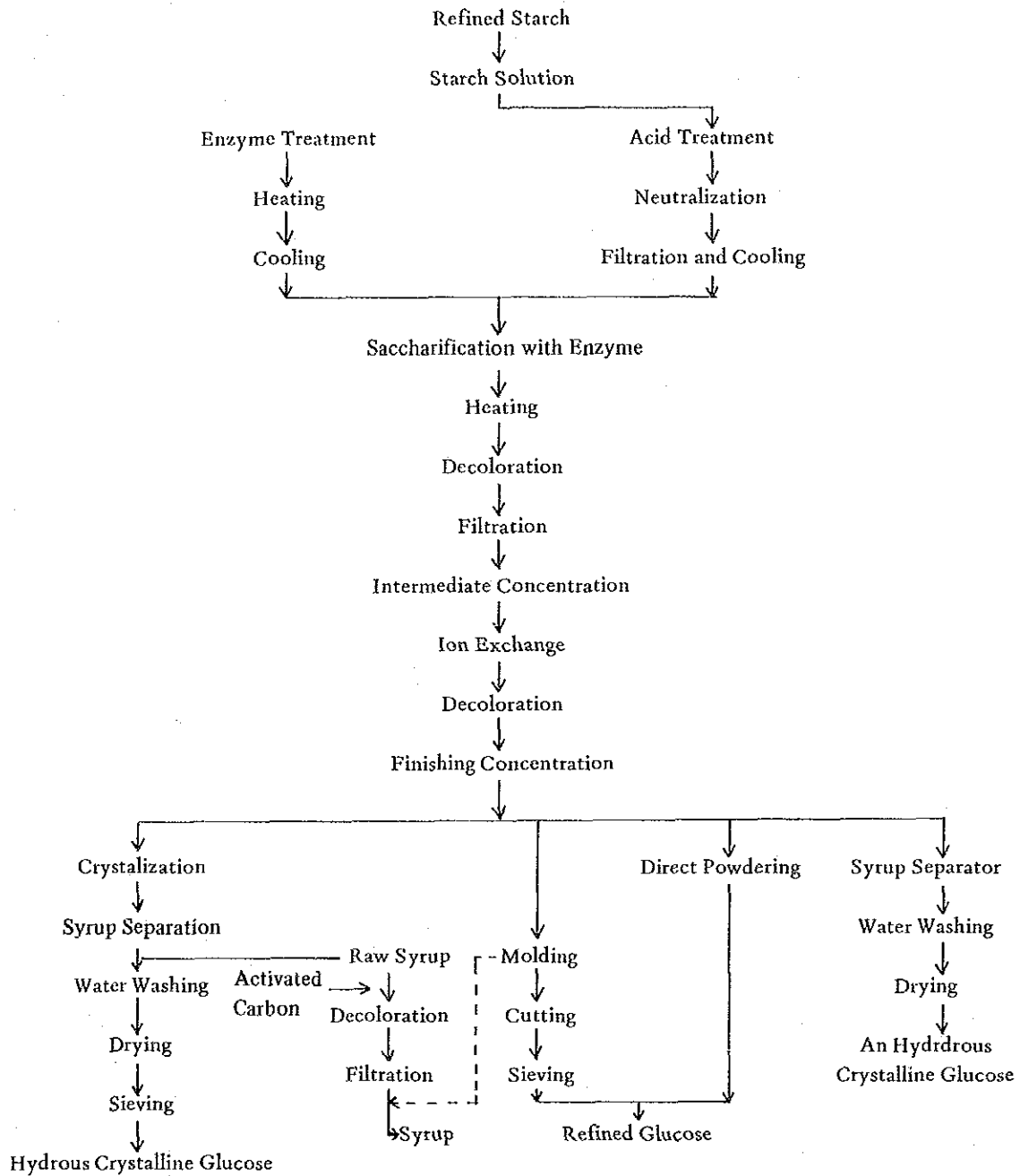


Fig. 2A-1-18 PROCESS FLOW SHEET FOR CARBONATED DRINK MANUFACTURE

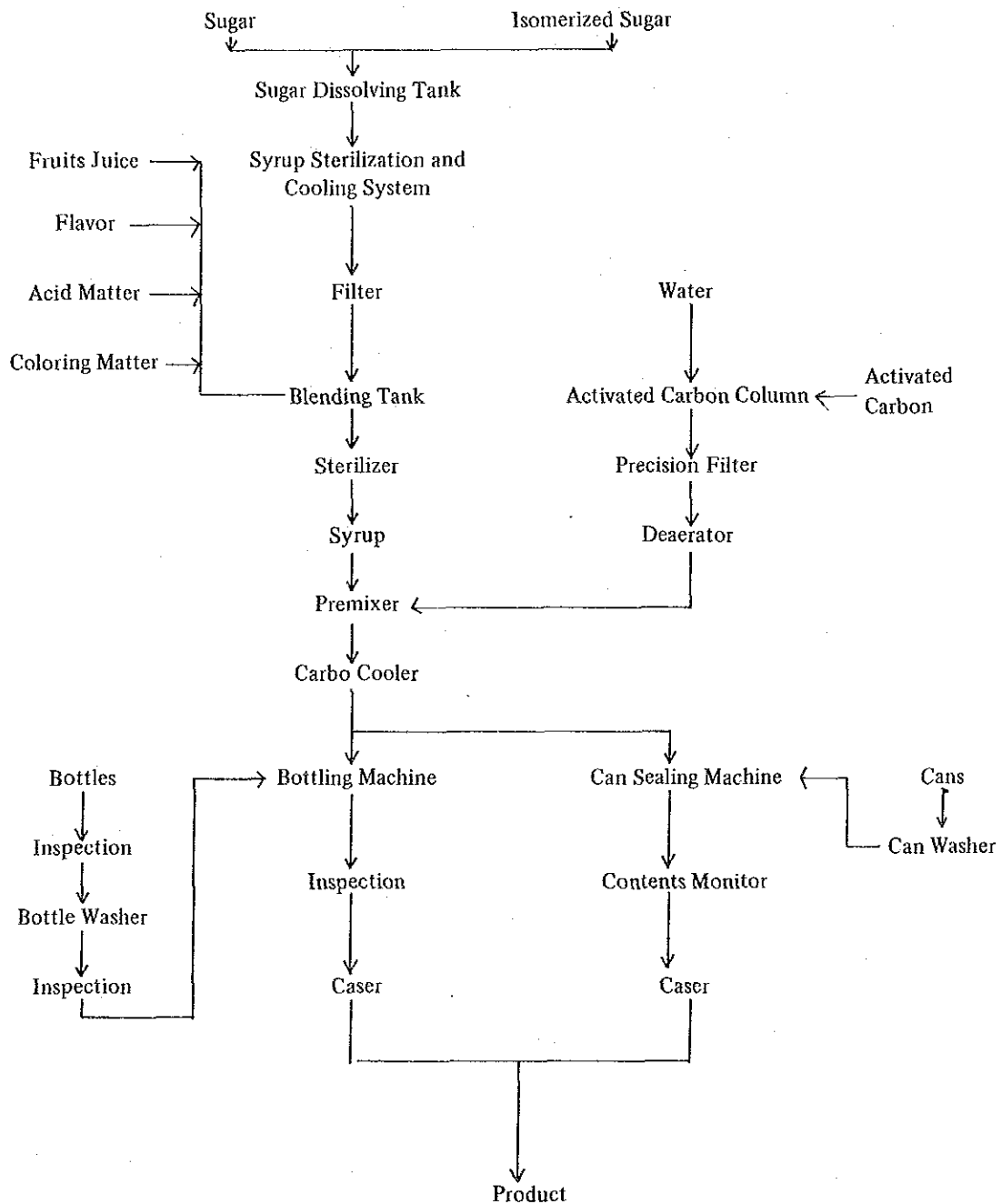
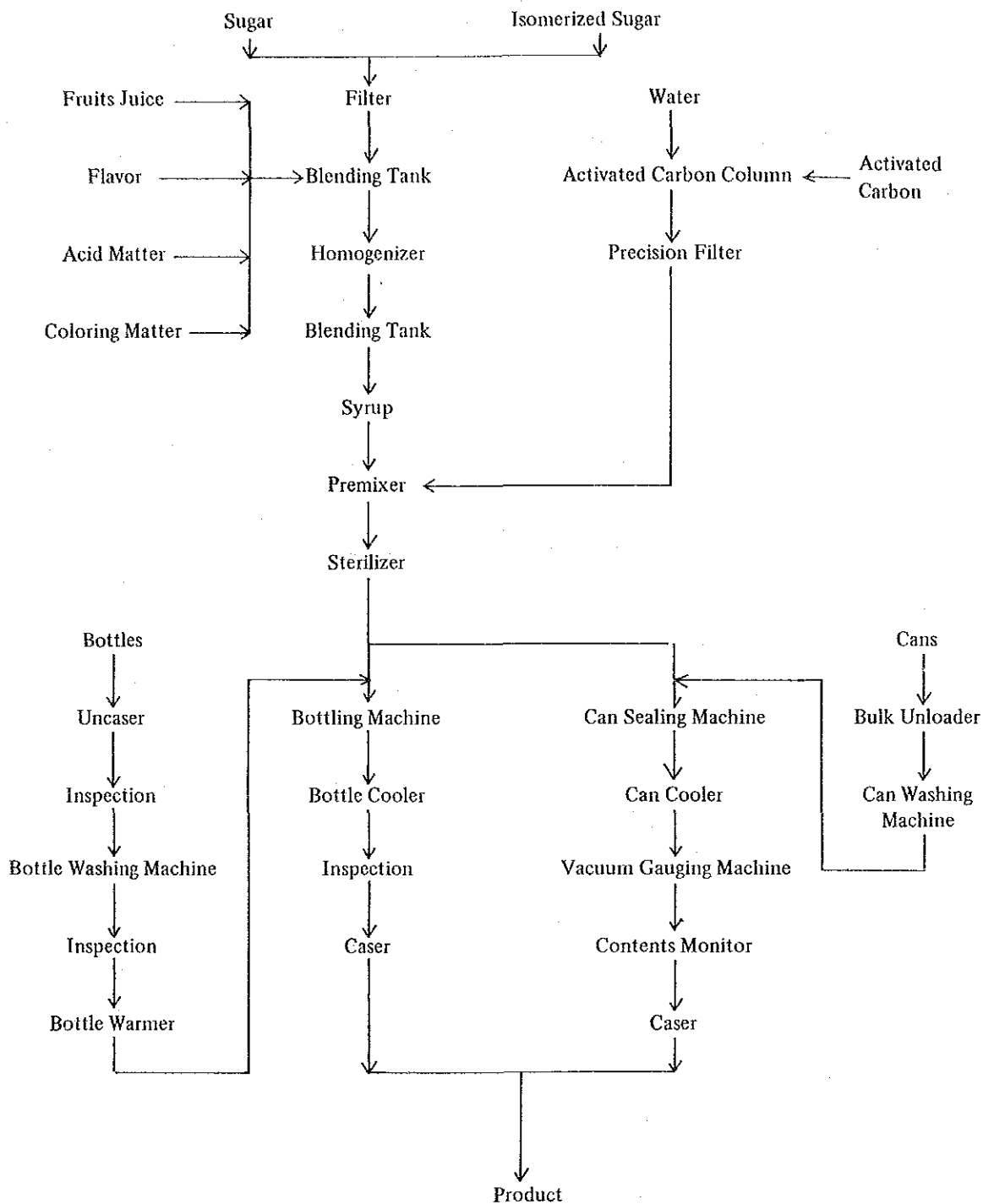


Fig. 2A-1-19. PROCESS FLOW SHEET FOR FRUITS DRINK MANUFACTURE





granular activated carbon of 5–10 times the volume of powdered activated carbon will be necessary, but the treatment proves economical since granular activated carbon can be regenerated.

e) Application to Manufacture of Glucose

Fig. 2A-1-17 shows a typical process for manufacturing glucose by using powdered activated carbon (starch isomerization process).

f) Application to Carbonated Drinks and Fruit Drinks

Water and sugar refined to very high levels are used in carbonated and fruit drinks in order to prevent disagreeable flavor and sedimentation. Activated carbon and a precision water filtration system are employed for water treatment. Fig. 2A-1-18 shows an example of manufacturing carbonated drinks, and Fig. 2A-1-19 an example of a process for manufacturing fruit drinks.

### 2.4.3 Liquid-Phase Refining in Chemical Industry

Activated carbon is also used widely in the chemical industry. Table 2A-1-17 shows examples of these applications together with their effects.

When using activated carbon in liquid phase for refining in chemical and other industries, excluding the food processing industry, the purpose will be not only for the decoloration and deodorization of products but as well to improve product storage stability (measures against discoloration, quality deterioration, etc.), improvement of purity, inhibition of side reactions and removal of factors responsible for harmful effects of medicine.

It is also employed for the decoloration and refining of synthetic resin plasticizers and industrial oils.

In the rubber industry and dyeing industry, powdered activated carbon is used to prevention of migration or secondary staining by additives and coloring matter. That is, in this case, the characteristic of activated carbon to adsorb and retain organic components and coloring matter is utilized.

The adsorption and refining effects of activated carbon are also utilized in cases where the circulated use of liquids in distillation or vaporization systems is attended with the

Table 2A-1-17 LIQUID-PHASE REFINING IN CHEMICAL INDUSTRY

Industry	Material	Operation and Improving Effect					
		Decoloring	Deodorization	Colloid Removal	Removal of Foaming Substance	Reutilization	Others
Medical Drug	Antibiotic Substances	o	o	o			Purity, Yie Stability
	Sulpha Drugs, Alkaloids	o	o	o			
	Vitamins, Hormons	o	o	o			”
	Inoculation Drugs						Removal of Pyrogen
Oil and Detergent	Mineral Oils, Detergent	o	o	o		o	
	Waxes	o	o	o			
	Surface Active Agents	o	o				
	Plasteizer	o	o	o	o		
	Hardened Oil	o	o	o	o		
	Lanolin, Caster Oil	o	o	o	o		
	Glycerine	o	o	o	o		
Rubber	Regenerated Rubber						Inhibition of Migration of Chemical
Petroleum Refineries, Chemical Industry	Liq. Petroleum Distill	o	o				Desulfurization
	Scrubbing Liq. Acids	o		o	o	o	
	” Salts	o		o	o	o	
	” Amines	o		o	o	o	
	Waste Oil	o		o	o	o	
High Polymer	Polymer, Synthetic Fiber	o	o				Inhibition of Side Reaction
	Raw Materails and Intermediate						
	Spinning Bath	o	o	o		o	
	Solution for Treatment	o	o	o		o	
	Solvent	o	o	o		o	
Dyestuff and Dyeing	Intermediate					Purity Yield	Inhibition of Side Reaction Inhibition of Permeance
	Washing Water	o					
Inorganic Chemicals	Phosphoric Acid, Boric Acid, Hydrochloric Acid	o	o				Removal of Org. Substance
	Alum, Alkali, Carbonates Hydrogen Peroxide						
Metal Processing	Metal Cleaning			o	Removal of Oil	o	Removal of Decomp. Sub.
	Plating Solution				”	o	
Dry Cleaning	Solvent	o		o		o	Removal of Acid
Mining	Flotation Solution				Removal of Agent		Control of Solution
Special Application	Gastroenteric Drugs, Poison Antidotes, Feed.						

formation of foaming substances or accumulation of coloring substances.

When manufacturing organic acids such as citric acid for use as a food additive, the activated carbon's refining effect is utilized to prevent those acids from giving disagreeable colors and odors to foods.

In the textile and drycleaning industries, activated carbon is used for the decoloration and refining of the circulating liquids containing bleaching agents, spinning bath agents or detergents, with the purpose of improving the textile product's luster and final washing effect.

Activated carbon for medical use has an antidotal effect of adsorbing toxic substances in the body, so it is useful for curing food poisoning, also for curing acute poisoning caused by erroneous swallowing or eating of toxic substances such as agricultural chemicals, mercuric chloride, strychnine, phenol and poisonous mushrooms.

#### 2.4.4 Collection and Recovery in Liquid Phase

Various kinds of valuable substances are adsorbed and desorbed by using activated carbon in liquid phase. The conditions for adsorbing and desorbing those substances are summarized as follows:

- (1) Changing the pH value or temperature of the liquid.
- (2) Replacement and adsorption of other substances which are easier to be adsorbed than the target substance.
- (3) Conversion of the target substance into one that is easier to dissolve.
- (4) Transforming the target substance into one that is easier to be desorbed by adopting methods such as neutralization, oxidation, reduction and formation of their salts.
- (5) Desorbing the target substance by bringing about changes in the temperature, degree of vacuum and pressure.
- (6) Recovering the target substance as residue by burning activated carbon.
- (7) Adopting a method that combines two or more methods described above.

Activated carbon is frequently compared with ion exchange resins, activated earth kaolin and zeolite, especially in connection with factors such as economy and product purifying effect. Whereas ion exchange resins in principle lend themselves to easier adsorption and desorption, activated carbon is regarded as being comparatively difficult for use in desorption. Therefore, owing to its higher costs, activated carbon is employed in liquid phase for collecting and recovering substances having relatively high values. Table 1A-1-18 shows typical examples of these applications.

**Table 2A-1-18 EXAMPLE OF COLLECTION AND RECOVERY  
IN LIQUID**

Industry	Objective Materials
Medical Drug	Antibiotic Substance, Vitamines, Hormons, Enzymes Nucleic Acid, etc.
Food Processing	Nucleic Acid Seasonings
Town Gas	Phenols
Metallurgical and Mining	Au, Ag, Pd, Os, Hg, Pb
Miscellaneous	Organic Solvent in Water, Monomer in Water, Hg in Flue Gas

#### 2.4.5 Treatment of City Water

It was in about 1925 that activated carbon was first used for city water purification. Subsequently, in 1927, meat processors and other food processors in Chicago suffered from heavy economic losses through the return of products by consumers since these processors had used water that contained the smell of chlorophenol formed by the reaction between the phenol existing in the raw water and the chlorine used for water treatment.

Water treatment by use of powdered activated carbon solved the problem and provided drinking water of good quality, so this method came to be adopted by water purification plants throughout the United States. Thus, water treatment through filtration with granular activated carbon started in Western countries, but subsequently shifted to the use of powdered activated carbon.

In Japan, where natural water of good quality had been available, there had been no need of using activated carbon for water treatment until recently, and it was only from about

1960 that deodorization treatment by powdered activated carbon was started. Large-scale water treatment with powdered activated carbon was started by the Tokyo Municipal Government in 1962 at its Tamagawa Water Purification Plant, where activated carbon was used for solving the foaming problem caused by sodium alkyl benzene sulfonate (ABS)-based detergent. Later, in a different region, powdered activated carbon was used for removing the odor caused by phenol contained in pulp waste effluent.

At about this same time, the problem of foul odor occurred in lakes of various regions due to nutritional enrichment of water which triggered the popular acceptance of the method of water treatment based on the use of powdered activated carbon.

More recently, the problem by trihalomethane broke out, which is directing attention on the effects of powdered activated carbon. Granular activated carbon is also regarded as being effective for this purpose. When treating city water with activated carbon, the use of powdered activated carbon will be more economical when used intermittently over a short period of time, but when treating highly polluted water over a long period of time, the use of granular activated carbon is regarded as being more advantageous since it lends itself to regeneration with ease.

Pollution of city water by chlorine-based solvents such as trichloroethylene has become a problem recently, so the Ministry of Public Welfare of Japan has set temporary standards for water quality and, at the same time, has decided to adopt various countermeasures such as the conversion to some other water source and the adoption of water purification methods such as by aeration and activated carbon treatment, in the event water pollution proceeds beyond temporarily prescribed quality standards.

#### 2.4.6 Treatment of Waste Water

In the industrial field, especially in the petroleum refining and petrochemical industries, activated carbon is being used to remove coloring matter as well as residual organic substances (hydrocarbon derivatives, phenol derivatives, etc.) which cannot be removed from industrial waste water by other methods. Activated carbon is also being used trially to treat waste municipal sewerage water for regeneration or for improving the water quality.

#### 2.4.7 Recovery of Solvents

Concentrated solvent vapor can be recovered by scrubbing with a solvent having a high boiling point, and water-soluble solvents by water-washing. However, with diluted solvent

vapor of 1–20 g/m<sup>3</sup>, the use of activated carbon serves as an economical means for recovery. That is, up to as much as 92–98% of the solvent vapor can be recovered, and the recovery cost runs up to only 5–20% of the cost of purchasing a new solvent. Table 2A-1-19 shows an example of the running costs involved in solvent recovery.

#### 2.4.8 Deodorization

Activated carbon has been used for long ago for the removal of hazardous gases and foul odors on small scales. Recently, various kinds of activated carbon impregnated with chemicals have been developed which feature excellent adsorbability and removal to low concentration rates by employing the adsorption method of giving chemical changes to the target substance to be adsorbed.

Impregnated activated carbon was developed long ago for the military purpose of providing protection against poison gas, but has come into popular acceptance more recently from the need of removing foul odors from our living environments.

For example, sulfur impregnated activated carbon is used for removing mercury vapor in hydrogen gas from water electrolysis, natural gas, refuse and activated sludge incineration exhaust gas. Meanwhile, acid- and alkali-impregnated activated carbon products are respectively employed for improving the adsorbabilities against alkaline or acidic odor components of substances such as ammonia, amines and hydrogen sulfide.

Table 2A-1-20 shows examples of impregnated activated carbon products employed for deodorization. These products are used independently for deodorization, or the gas to be treated is first washed with an acid, alkali or sodium hypochlorite and then passed through an activated carbon-packed column.

Table 2A-1-21 offers a comparison of adsorbabilities at break point between ordinary activated carbon and impregnated activated carbon, and Table 2A-1-22 some examples of application of impregnated activated carbon for deodorization.

When treating odors of relatively low concentration, the adsorbability of activated carbon is retained over a long period of time. Therefore, granular activated carbon has been used popularly for this fields of applications, but the use of fibrous activated carbon has come under study more recently. Fibrous activated carbon using polyacrylonitrile as a raw material is known to be especially effective for the adsorption and removal of methyl mercaptan odor.

**Table 2A-1-19 GENERAL SYSTEM RUNNING COSTS FOR SOLVENT RECOVERY (PER TON OF SOLVENT)**

Steam	1.3 – 8 TONS
Electricity	0 – 350 kWh
Water	30 – 300 m <sup>3</sup>
Activated Carbon	0.5 – 1.0 kg

More electricity is used by case of steam recovery system.

**Table 2A-1-20 IMPREGNATED ACTIVATED CARBON FOR DEODORIZATION**

Impregnant	Raw Material	Shape	Particle Size	Linear Velocity of Gas	Objective Substance	Regeneration
Acid	Coconuts shell	Crushed	2.4 – 4.7 mm	0.3 m/s	Ammonia Trimethyl Amine	Possible
Acid	Coal	Sphere	3 – 8	0.4	Ammonia Trimethyl Amine	Possible
Alkali	Coconuts shell	Crushed	2.4 – 4.7	0.3	Hydrogen Sulfide Methyl Mercaptane	Possible

**Table 2A-1-21 COMPARISON OF IMPREGNATED WITH ORDINARY ACTIVATED CARBON ON ADSORPTIVE CAPACITY AT BREAK POINT**

Particle Size		Ordinary Carbon		Impregnated Carbon	
		2.4 – 4.7 mm		2.4 – 4.7 mm	
Odor Component		H <sub>2</sub> S	CH <sub>3</sub> SH	H <sub>2</sub> S	CH <sub>3</sub> SH
Concentration		20 ppm	5 ppm	20 ppm	5 ppm
Contact Time	0.25 sec.	0.6 %	1.8 %	3.0 %	2.8 %
	0.5	3.4	4.2	12.2	6.6
	1.0	3.9	6.7	25.4	13.0
	1.5	4.1	7.1	29.6	17.6

**Table 2A-1-22 TYPICAL EXAMPLES OF APPLICATION OF  
IMPREGNATED ACTIVATED CARBON TO  
DEODORIZATION**

Objective Odor	Example
Organic Solvent, Hydrocarbons (Including Vapor Recovery)	Paint Manufacture, Painting, Printing, Adhesive Rubber and Polymer Processing, Metal Cleaning, Cleaning, Chemicals Manufacture.
Sewerage	Sewerage Plant, Waste Water Facility of Housing Complexes, Hotels and Buildings. (Odor of NH <sub>3</sub> , H <sub>2</sub> S and Mercaptans)
Refuse	Refuse Dumping Grounds (Foul Odors Emitted from Incombustible Refuse)
Animals	Cages for Containing Experimental Animals, Such as Mouse, Rat etc.
Industrial Emission of Fish Processing, Feed Plant, Food Processing, Spice and Perfume Plant	Ventilation Systems of Plant
Human Body, Hospital, Laboratory	Condominium, Office Building, Hospital, Homes for Elderly, Laboratory (Phenol, Amine Odor)
Tar and Asphalt Utilization	Civil Engineering Works, Building Material Manufacturing



#### 2.4.9 Gas Separation

Carbon molecular sieves (CMS) are generally made of coal-based activated carbon, and those having pore diameters of 3–5 Å are used for the manufacture of nitrogen. When air is separated by the pressure swing method, the nitrogen purity is as high as 95–99%, and oxygen-enriched air is obtained as byproduct.

#### 2.4.10 Activated Carbon for Cigarette Filters

Activated carbon cigarette filters essentially consist of a combination of activated carbon and fibrous substance, and are physically ideal if they have a minimal air passage resistance and maximal aerosol particle capturing efficiency.

It was in 1954 that activated carbon cigarette filters were first used in the United States. The Central Laboratory of the Japan Monopoly Corporation measured the smoke component adsorbabilities of various kinds of activated carbon products since 1964 and have successively announced the results of its research conducted together with sensory tests. According to the findings, coconut shell activated carbon displays excellent performance. Activated carbon having large bulk density, minimal inorganic substance and acetone adsorbability of up to 30% is the most ideal, and activated carbon of higher acetone adsorbability features excess adsorbability with respect to all organic volatile substances.

There are various types of cigarette filters. Some consist of a mixture of inactive substances having the same particle size as that of granular activated carbon. Some are a mixture of granular activated carbon with other substance using a kind of binder. In some cases powdered activated carbon, is stucked on fibrous resin.

Fig. 2A-1-20 shows the structure of the dual type and triple type filters. In Japan, the cigarette brand Seven Stars uses the former type filter, and Cabin 85 and Lark (U.S.) the latter type filter. As of fiscal 1983, there were eleven cigarette brands using activated carbon filters in Japan. The total number of cigarettes consumed ran up to a total of 200 billion cigarettes, for which about 10,000 tons of activated carbon were used. (Refer to Table 2A-1-23.)

Fig. 2A-1-20 STRUCTURE OF ACTIVATED CARBON CIGARETTE FILTER

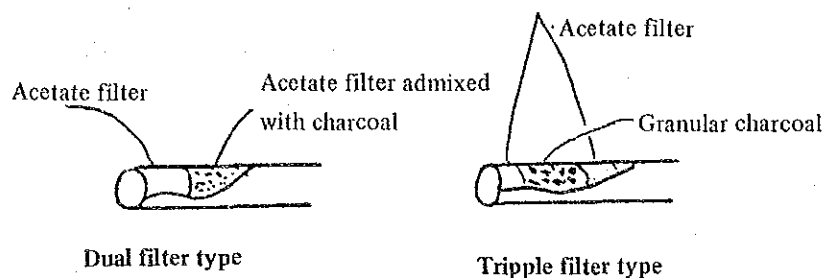


Table 2A-1-23 CIGARETTES WITH ACTIVATED CARBON FILTER  
IN JAPAN

Fiscal Year 1984

	Piece (Million)	Quantity of Charcoal (Supposed)
Cabin	552	20
Cabin Mild	—	—
Mine	2,118	60
Cabin 85	10,573	400*
Cabin 85 Mild	5,449	350*
Tender	2,077	60
Mild Seven Select	9,544	300
Caster	16,887	400*
Caster Special	19	—
Seven Stars	42,211	2,500*
Mild Seven	128,091	7,500*
<b>Total</b>	<b>217,521</b>	<b>11,590</b>

\* Calculated from obserb. Others are supposed to 30 mg/piece. The quantity contains moisture.

\* Cabin 85 and Cabin Mild are tripple type, others are dual type.

## 2.5 Trends in Demand for Activated Carbon

The consumption of activated carbon depends on business conditions. The annual consumption of activated carbon in Japan, Europe and the United States in recent years were about 50,000 tons, 80,000 tons and 80,000 tons respectively. In Japan, roughly 30,000 tons of this consumption volume are being used for improving living environments in one way or another.

Regarding the shares of powdered and granular activated carbon in various fields of industries in Japan, their shares are 6,000 tons and 1,300 tons, respectively, in the industrial chemicals industry, and 2,800 tons and 13,000 tons, respectively, in the sector of water treatment. In the fields of sugar refining and glucose manufacture (including starch sugar), powdered activated carbon accounts for a total demand of roughly 3,000 tons/yr, whereas there is no statistical data for granular activated carbon in this particular field. Accordingly, the demand for powdered activated carbon is overwhelmingly large in fields related directly to manufacturing processes, while on the other hand the demand for granular activated carbon runs up to as much as 28,000 T/Y in fields related to gas adsorption and water treatment.

The future trend in the demand for powdered activated carbon appears to suggest, not a mode of competition with granular activated carbon as hitherto, but rather the development of its new, unique sources of demands. Specifically, since no large increase is anticipated in demands in connection with manufacturing processes, the trend in the growth of demands for powdered activated carbon will rest largely on how much the demand volume can be increased particularly in the field of improvement of living environments.

Surveys and discussions relating to the disruption of our living environments, especially pollution of underground water by chemical substances, have come to be conducted actively in recent years not only in Japan but as well in Western countries, which suggests establishment of stricter regulations and enforcement of stricter governmental administrative guidance.

This trend relates primarily to preventing water pollution caused by burying of chemical wastes and discharge industrial waste water. However, tightening burying standards will force industrial plants and municipal refuse treatment plants to adopt methods for self-treatment of wastes and refuse on their own, which may increase water and air pollution. That is, waste water treatment demands the adoption of sophisticated technologies. This will ultimately lead to the increased use of activated carbon.

Incidentally, in Japan, the pollution of service water by trihalomethane (cancer substance) and underground water by halogenized solvents have become problematical. The trihalomethane problem can be coped with by establishing granular activated carbon treatment plants in water purification facilities, but this measure is restricted by land procurement and investment cost. Treatment with powdered activated carbon is also attracting attention.

Recently a technology for efficient treatment by use of powdered activated carbon has been developed. This technology is applicable by using powdered activated carbon directly in the biotic treatment tanks presently being employed for secondary water treatment, and has the advantage of eliminating the necessity of constructing an entirely new water treatment facility. Upon the practical application of this technology for secondary water treatment henceforth, chances are that the pattern of demand for activated carbon would be changed to result in a big demand for powdered activated carbon.

In fact, in Kita-Kyushu City, an activated carbon facility has already been installed for service water deodorization and removal of trihalomethane-causing substances.

Other conceivable factors for increasing the consumption of powdered activated carbon include the improvement of powdered activated carbon regeneration technologies and the development of new products such as admixed products of powdered activated carbon with silica gel or molecular sieves.

#### **Bibliography**

- 1) Activated Carbon Industry by Kitagawa, Yanai, Eguchi and Kunibe, published by Jukkagaku Kogyo Tsushinsha (1974).
- 2) Activated Carbon Textbook by Yanai, published by Nikkan Kogyo Shinbun Sha (1976).
- 3) Activated Carbon by Carbon Material Society, published by Kodansha (1975).
- 4) Activated Carbon by J.W. Hassler, translated by Oda and Eguchi, published by Chemical Publishing Co. (1963).
- 5) Chemical Engineering article by Nishino, 29, 484 (1984).
- 6) Chemical Engineering article by Ishizaki, 29, 497 (1984).

- 7) Chemistry and Industry by Kitagawa, 32, 177 (1958).
- 8) Designing of Adsorbents and Adsorption Manipulation by Yanai, published by Gihodo.
- 9) Lumber Industry by Yanai, 23, 162 (1968).
- 10) Carbon by Itoga, 67, 148 (1971).
- 11) Water Treatment Technology by Yanai, 15, 313 (1974).
- 12) Fluidization by M. Leva, published by McGraw-Hill (1959).
- 13) Thermal Unit Manipulation (Vol. 1), published by Maruzen (1976).
- 14) Fluidized Beds by Shirai, published by Kagaku Gijutsusha (1982).
- 15) Chemical Plants by Sasaoka, 27 (5), 80 (1983).
- 16) Activated Carbon Technology Research Data No. 77 of Daikoken by Nakano, 1984.
- 17) Securities Report by Kirin Beer Co., 1984.
- 18) Chemical Engineering article by Mizushima, 29 (7), 81 (1984).
- 19) Fuel Association Magazine article by Sasaoka, 62, 335 (1983).
- 20) Water Treatment Technology article by Kitagawa, 11 (10), 35 (1970).
- 21) Water Treatment Technology article by Takahashi, 19 (4), (1978)
- 22) Journal of New England WWA article by R.T. Allen, 96 (4), 286 (Dec. 1982).
- 23) Chemical Engineering (Sept. 17) 20, 1984, etc.
- 24) European Chemical News, 42 (1125) (April 2), 16 (1984), etc.
- 25) Suido Kyokai Zasshi article by Yasumoto, 53 (6) 21, 1984.



AGRICULTURAL LAND UTILIZATION (CROPS AREA HARVESTED)\*  
 BY KIND OF CROPS, PHILIPPINES 1972 TO 1982  
 (In thousand hectares)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982 <sup>a</sup>
<b>PHILIPPINES</b>	9,382	9,213	10,117	10,760	11,450	11,838	11,892	12,040	12,133	11,961	12,205
Food Crops	6,561	6,345	7,124	7,629	8,015	8,163	8,102	8,163	8,222	8,081	8,236
Palay	3,246	3,112	3,437	3,539	3,579	3,548	3,602	3,561	3,537	3,459	3,433
Corn	2,432	2,325	2,763	3,003	3,257	3,321	3,222	3,252	3,201	3,239	3,361
Fruits & Nuts Except Citrus	385	389	351	378	434	441	431	476	491	494	507
Citrus	19	19	19	20	22	22	23	25	25	25	25
Rootcrops	259	266	314	351	356	451	461	481	485	477	480
Veg. Except Onions & Potatoes	52	54	52	55	57	56	57	53	53	51	53
Onions	8	8	10	13	12	12	13	16	16	15	16
Ginger	3	3	3	4	5	5	5	5	6	6	6
Irish Potatoes	4	3	4	3	5	3	3	4	4	4	4
Beans & Peas	45	47	45	55	63	63	63	63	66	69	69
Coffee	55	61	65	65	77	76	85	95	102	119	135
Cacao	7	7	7	7	4	4	4	4	5	7	11
Peanuts	33	33	37	55	61	63	48	54	55	39	55
All other food crops	16	17	18	21	85	88	85	85	85	87	88
Commercial Crops	2,821	2,868	2,993	3,131	3,446	3,685	3,790	3,877	3,911	3,880	3,969
Coconut	2,126	2,133	2,208	2,280	2,521	2,728	2,890	3,064	3,126	3,105	3,182
Sugar Cane	441	455	491	536	533	567	521	451	425	421	471
Abaca	145	163	170	180	244	250	244	235	238	230	207
Tobacco: Virginia	32	32	29	36	36	31	31	30	24	23	24
Tobacco: Native	46	52	59	49	52	45	43	37	37	33	33
Ramie	2	2	2	2	0.2	0.2	0.3	0.3	0.2	0.5	0.7
Rubber	25	26	33	45	55	59	54	54	54	54	57
Maguay	3	3	3	3	3	3	3	4	3	3	3
Kapok	2	1	1	1	1	0.7	0.8	0.7	0.7	0.8	0.8
Cotton	6	6	6	0.3	0.4	0.5	0.2	0.4	0.4	0.9	10.0
Castor	—	—	—	0.3	0.4	0.5	0.6	0.6	0.8	0.8	0.8

<sup>a</sup> Preliminary estimates.

<sup>b</sup> Less than 0.1 thousand hectares.

\* Except for tree crops.

<sup>c</sup> Revised.

SOURCE OF DATA: Bureau of Agricultural Economics  
 Ministry of Agriculture

COMPARATIVE ANNUAL VALUE OF PHILIPPINE EXPORTS BY COMMODITY, 1974-1982  
(In FOB Thousand U.S. Dollars)

	1974	1975	1976	1977	1978	1979	1980	1981	1982
Total Philippine Exports	\$2,724,898	\$2,294,470	\$2,573,670	\$3,150,887	\$3,424,876	\$4,601,190	\$5,787,787	\$5,722,157	5,020,593
Logs and Lumber	\$ 246,389	\$ 194,100	\$ 203,417	\$ 200,413	\$ 230,059	\$ 342,765	\$ 273,207	\$ 202,012	202,173
Copper Concentrates	393,184	212,081	265,878	267,801	250,387	440,360	544,974	429,376	312,447
Sugar	737,365	580,736	429,239	511,705	196,903	211,553	624,034	586,560	416,028
Copra	139,784	172,318	149,722	200,525	135,604	89,128	47,253	33,634	49,218
Coconut Oil	380,732	230,299	289,713	412,238	620,572	742,513	566,848	533,466	401,026
Gold	74,309	76,354	65,348	71,268	75,738	103,280	239,149	215,183	160,720
Plywood	26,089	20,602	43,165	40,589	70,613	107,183	103,843	110,717	66,984
Desiccated Coconut	60,300	30,429	37,494	90,047	81,889	107,001	115,991	101,789	88,283
Bananas	45,470	73,104	75,618	72,461	84,127	96,684	114,184	124,024	145,108
Copra Meal/Cake	27,887	33,331	54,523	58,151	69,059	85,519	81,391	80,758	72,116
Leaf Tobacco	29,828	26,643	27,513	27,884	29,297	32,906	28,819	49,149	46,718
Canned Pineapple	30,625	34,705	46,739	55,908	58,786	73,756	62,098	88,388	87,550
Abaca Unmanufactured	37,533	14,544	19,477	17,403	15,288	25,350	26,955	18,719	20,125
Molasses	27,671	33,878	24,410	20,458	16,045	26,890	32,868	37,830	24,780
Portland Cement	26,644	28,140	18,188	23,516	25,736	12,676	35,747	21,276	22,465
Total Coconut Products	\$ 608,703	\$ 468,377	\$ 542,241	\$ 703,402	\$ 908,812	\$ 1,029,414	\$ 820,471	\$ 755,445	584,127
Forest Products	332,457	257,748	308,875	304,146	375,499	564,073	499,989	408,936	382,585
Sugar Products	766,401	616,169	456,137	534,956	215,604	240,003	658,698	608,667	444,529
Mineral Products	518,649	332,131	430,944	519,889	533,395	819,892	1,168,868	838,771	636,651

1. Includes other coco-based products.

SOURCE: OF BASIC DATA: Central Bank of the Philippines,  
Manila



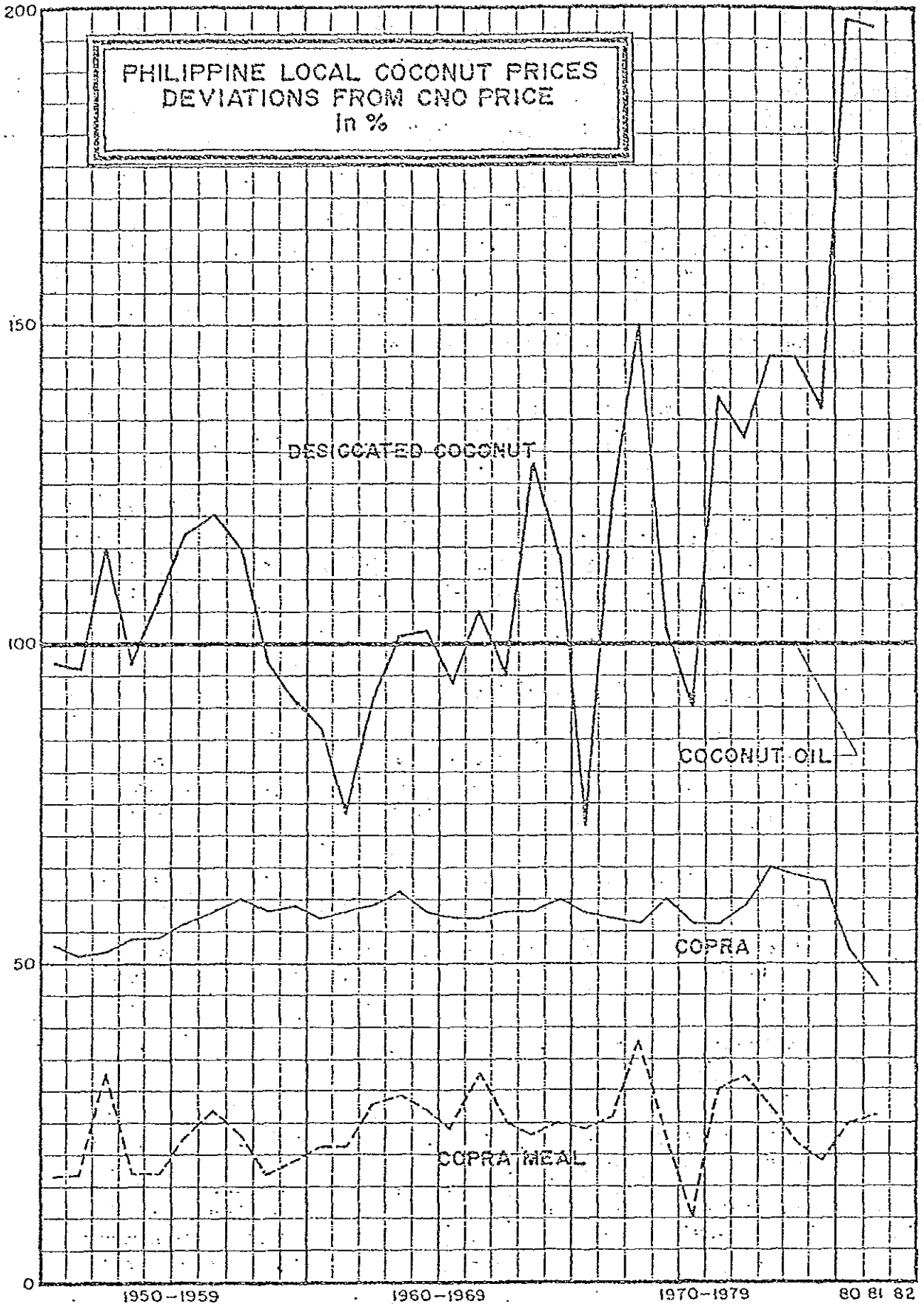
YEAR	Total	COPRA		COCONUT OIL (COPRA EQUIVALENT)		RESPECTIVE SHARE TO TOTAL EXPORT VOLUME, 1968-1982		(Volume in M.T.)	
		Percent	Copra	Percent	Coco-Oil	Percent	Share of Copra	Percent	Share of Coco-Oil
1968	1,117,749	100	681,417	60.90	436,333	39.04	67.90	382.00	
1969	898,312	100	553,485	61.61	344,828	38.39	68.62	375.64	
1970	962,604	100	423,464	43.99	539,120	56.01	49.00	548.04	
1971	1,364,058	100	710,530	52.09	653,528	47.91	58.02	648.79	
1972	1,724,995	100	968,469	56.14	756,525	43.86	62.53	429.16	
1973	1,419,267	100	727,980	51.29	691,287	48.71	57.13	479.61	
1974	1,008,359	100	308,482	30.69	698,877	69.31	34.18	678.18	
1975	1,786,806	100	832,612	46.60	954,194	53.40	51.90	522.50	
1976	2,240,044	100	867,025	38.71	1,373,019	61.29	43.12	599.71	
1977	1,835,505	100	559,889	30.50	1,275,616	69.50	33.97	680.04	
1978	1,975,771	100	379,777	19.22	1,595,994	80.78	21.41	790.41	
1979	1,426,511	100	144,850	10.15	1,281,661	89.85	11.31	879.16	
1980	1,574,064	100	123,258	7.83	1,450,806	92.17	8.72	901.66	
1981	1,767,891	100	108,385	6.02	1,661,306	93.98	6.71	819.57	
1982	1,698,045	100	191,788	11.30	1,506,257	88.70	12.59	867.91	

NOTE: Discrepancy in the total is attributed to the rounding of figures.

SOURCE OF BASIC DATA: Trade and Markets Department, Philippine Coconut Authority

RPC COCONUT PRODUCTS: EXPORT VOLUME AND VALUE, BY SECTOR AND BY DESTINATION, MONTHLY 1982  
(Volume in Metric Tons - Value in FOB US\$)

	SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		TOTAL	
	Volume	Value	Volume	Value	Volume	Value	Volume	Value	Volume	Value
<b>COPRA:</b>										
Europe	13,372	3,351,038	20,278	5,170,582	4,000	967,000	5,800	1,434,000	191,788	52,857,001
U.S.S.R.	10,022	2,403,638	17,478	4,416,332	2,000	447,000	5,800	1,434,000	159,043	43,153,181
Japan	3,150	827,400	2,100	550,200	2,000	520,000	—	—	10,200	3,417,000
Taiwan	200	60,000	700	210,000	—	—	—	—	14,250	3,865,100
Others	—	—	—	—	—	—	—	—	5,207	1,546,430
<b>TOTAL</b>	<b>64,197</b>	<b>25,446,144</b>	<b>73,635</b>	<b>29,467,287</b>	<b>65,688</b>	<b>24,036,262</b>	<b>94,717</b>	<b>34,696,380</b>	<b>948,942</b>	<b>410,587,703</b>
<b>COCONUT OIL:</b>										
U.S.A.	37,186	14,935,710	24,892	9,830,638	35,747	13,204,950	29,454	10,608,277	400,454	172,633,433
Europe	24,790	9,391,631	29,891	11,063,859	25,122	8,732,331	33,198	11,652,220	369,956	154,015,135
U.S.S.R.	—	—	9,000	4,509,000	—	—	19,999	7,696,409	84,893	40,704,820
P.R.O.C.	—	—	3,556	1,349,250	—	—	3,656	1,268,750	21,336	9,243,500
Japan	2,075	1,058,645	3,010	1,413,437	3,394	1,446,142	2,769	1,175,000	32,862	16,058,599
Australia	—	—	—	—	—	—	538	245,370	2,773	1,398,970
Others	146	92,158	3,036	1,301,173	1,405	572,839	5,203	2,050,354	36,552	16,533,446
<b>TOTAL</b>	<b>39,500</b>	<b>4,793,155</b>	<b>41,420</b>	<b>4,776,957</b>	<b>59,348</b>	<b>6,979,423</b>	<b>55,955</b>	<b>6,689,447</b>	<b>589,572</b>	<b>71,821,236</b>
<b>COPRA MEAL/CAKE:</b>										
U.S.A.	39,500	4,793,155	41,370	4,769,807	59,348	6,979,423	55,955	6,689,447	589,322	71,784,227
Europe	—	—	50	7,150	—	—	—	—	250	37,009
Japan	—	—	—	—	—	—	—	—	—	—
Others	—	—	—	—	—	—	—	—	—	—
<b>TOTAL</b>	<b>8,114</b>	<b>5,380,408</b>	<b>8,603</b>	<b>5,661,375</b>	<b>7,324</b>	<b>4,768,521</b>	<b>8,670</b>	<b>5,639,979</b>	<b>89,182</b>	<b>67,958,493</b>
<b>DESICCATED COCONUT:</b>										
U.S.A./Canada	4,859	3,275,078	5,036	3,369,808	4,507	3,012,502	4,901	3,273,693	47,415	37,276,464
Western Europe	1,978	1,236,800	2,279	1,398,786	1,531	942,744	2,386	1,468,005	25,391	17,680,377
Asia/Pacific	890	581,577	1,114	769,138	1,095	682,880	974	637,972	11,908	9,506,065
Middle East	268	174,778	174	123,643	175	104,005	398	245,909	3,139	2,418,985
Latin & Central America	131	112,175	—	—	16	13,790	11	14,500	644	611,258
Others	—	—	—	—	—	—	—	—	685	467,344
<b>TOTAL</b>	<b>1,724</b>	<b>239,367</b>	<b>1,734</b>	<b>250,003</b>	<b>2,157</b>	<b>285,443</b>	<b>1,933</b>	<b>274,134</b>	<b>21,961</b>	<b>3,192,795</b>
<b>COCO SHELL CHARCOAL:</b>										
U.S.A.	—	—	95	11,163	16	1,822	48	7,980	897	140,250
Europe	1,724	239,367	1,639	238,840	2,049	271,741	1,802	253,794	10,45	203,438
Japan	—	—	—	—	—	—	—	—	19,463	2,760,058
Others	—	—	—	—	92	11,880	85	12,360	556	89,050
<b>TOTAL</b>	<b>509</b>	<b>405,161</b>	<b>563</b>	<b>639,828</b>	<b>971</b>	<b>1,022,489</b>	<b>957</b>	<b>1,026,876</b>	<b>8,976</b>	<b>9,878,752</b>
<b>ACTIVATED CARBON:</b>										
U.S.A.	131	151,344	118	147,694	71	108,856	177	255,947	1,819	2,540,992
Europe	20	18,430	—	—	24	21,802	37	28,653	485	429,645
Japan	324	291,636	431	400,929	813	837,473	743	743,276	6,324	6,577,839
Others	34	33,751	14	11,205	63	54,358	—	—	348	331,176



Prepared by:UCAP Research  
-pmg

Appendix 3A-2

Import Tax Levied on Activated Carbon Importation

Import Tax = 30 % x Dutiable Value

Dutiable Value consists of the following:

- 1) Home consumption value  
(wholesale market price in exporting country)
- 2) 10 % of value 1)
- 3) Order charges  
Cost of material & labor in packing  
Inland freight in exporting country  
Other cost incurred from the factory to the pier

Appendix 3A-3

Home Consumption Value of Activated Carbon (Example, Oct. 1983)

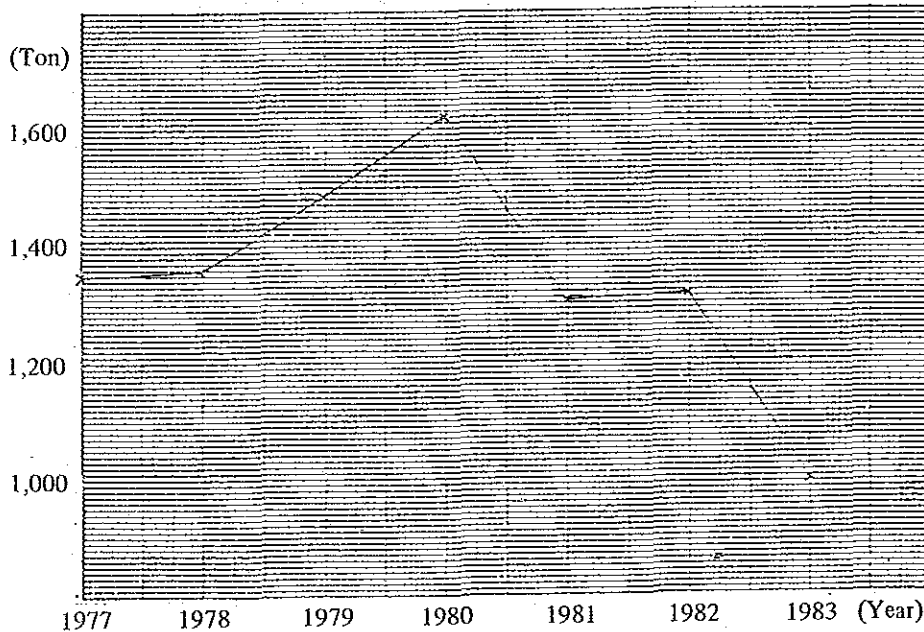
38.03 9.00 Activated Carbon

	(unit HCV) Home Consumption Value (US\$)	Country of Export
Activated Carbon "CAC" brand	1,200/MT	Taiwan
Grade CG 501	1,200/MT	"
Grade CF 501	1.20/kg	"
Activated Carbon Diahope S 80	2.18/kg	Japan
"    S 90	0.77/kg	"
"    007	0.66/kg	"
Activated Carbon Filcerb 100	0.75/lb	Germany
Granulated	1.62/kg	Japan
KV-0	1,436.00/MT	"
Industrial Grade	1,436.00/MT	"
"Myfie" supercol carbon	230.51/MT	U.S.A.

**IMPORT OF ACTIVATED CARBON**

Import of activated carbon in recent years was as follows:

	Volume (T)	Amount (US\$)	
		F.O.B.	C.I.F.
1977	1,351,011	1,126,875	
1978	1,362,173	1,399,792	1,573,888
1979	1,484,246	1,775,358	2,012,243
1980	1,620,482	2,578,107	2,824,304
1981	1,302,572	2,163,750	
1982	1,316,932	2,001,400	2,187,427
1983	997,446	1,579,961	1,701,637



**IMPORT OF ACTIVATED CARBON**

As observed from the table and graph shown above, annual import of activated carbon ranges from about 1,000 tons upto 1,600 tons with an average of 1,348 tons. It is considered that the decrease of import in 1983 was caused by the economic situation of the Philippines. So, the volume of import of activated carbon in 1983 does not show actual situation of the demand of activated carbon in the Philippines.

While as in 1981 and 1982, the economic situation was stable, the volume of import is considered to reflect the correct market situation of activated carbon in the Philippines.





PRESIDENTIAL DECREE NO. 705

REVISING PRESIDENTIAL DECREE NO. 389, OTHERWISE KNOWN AS THE FORESTRY REFORM CODE OF THE PHILIPPINES.

WHEREAS, proper classification, management and utilization of the lands of the public domain to maximize their productivity to meet the demands of our increasing population is urgently needed;

WHEREAS, to achieve the above purpose, it is necessary to reassess the multiple uses of forest lands and resources before allowing any utilization thereof to optimize the benefits that can be derived therefrom;

WHEREAS, it is also imperative to place emphasis not only on the utilization thereof but more so on the protection, rehabilitation and development of forest lands, in order to ensure the continuity of their productive condition;

WHEREAS, the present laws and regulations governing forest lands are not responsive enough to support re-oriented government programs, projects and efforts on the proper classification and delimitation of the lands of the public domain, and the management, utilization, protection, rehabilitation and development of forest lands;

NOW, THEREFORE, I, FERDINAND E. MARCOS, President of the Philippines, by virtue of the powers in me vested by the Constitution, do hereby revise the Presidential Decree No. 389 to read as follows:

SECTION 1. Title of this Code. - This decree shall be known as the "Revised Forestry Code of the Philippines".

SEC. 2. Policies. - The State hereby adopts the following policies:

a) The multiple uses of forest lands shall be oriented to the development and progress requirements of the country, the advancement of science and technology, and the public welfare;

b) Land classification and survey shall be systematized and hastened;

c) The establishment of wood-processing plants shall be encouraged and rationalized; and

d) The protection, development and rehabilitation of forest lands shall be emphasized so as to ensure their continuity in productive condition.

SEC. 3. Definitions. -

a) Public forest is the mass of lands of the public domain which has not been the subject of the present system of classification for the determination of which lands are needed for forest purposes and which are not.

b) Permanent forest or forest reserves refer to those lands of the public domain which have been the subject of the present system of classification and determined to be needed for forest purposes.

c) Alienable and disposable lands refer to those lands of the public domain which have been the subject of the present system of classification and declared as not needed for forest purposes.

d) Forest lands include the public forest, the permanent forest or forest reserves, and forest reservations.

e) Grazing lands refer to that portion of the public domain which has been set aside, in view of the suitability of its topography and vegetation, for the raising of livestock.

f) Mineral lands refer to those lands of the public domain which have been classified as such by the Secretary of Natural Resources in accordance with prescribed and approved criteria, guidelines and procedure.

g) Forest reservations refer to forest lands which have been reserved by the President of the Philippines for any specific purpose or purposes.

h) National Park refers to a forest land reservation essentially of primitive or wilderness character which has been withdrawn from settlement or occupancy and set aside as such exclusively to preserve the scenery, the natural and historic objects and the wild animals or plants therein, and to provide enjoyment of these features in such a manner as will leave them unimpaired for future generations.

i) Game refuge or bird sanctuary refers to a forest land designated for the protection of game animals, birds and fish and closed to hunting and fishing in order that the excess population may grow and restock surrounding areas.

j) Marine park refers to any off-shore area inhabited by rare and unique species of marine flora and fauna.

k) Seashore park refers to any public shore area delimited for outdoor recreation, sports fishing, water skiing and related healthful activities.

l) Watershed reservation is a forest land reservation established to protect or improve the conditions of the water yield thereof or reduce sedimentation.

m) Watershed is a land area drained by a stream or fixed body of water and its tributaries having a common outlet for surface run-off.

n) Critical watershed is a drainage area of a river system supporting existing and proposed hydro-electric power and irrigation works needing immediate rehabilitation as it is being subjected to a fast denudation causing accelerated erosion and destructive floods. It is closed from logging until it is fully rehabilitated.

c) Mangrove is a term applied to the type of forest occurring on tidal flat along the sea coast, extending along streams where the water is brackish.

p) Kaiingin is a portion of the forest land, whether occupied or not, which is subjected to shifting and/or permanent slash-and-burn cultivation having little or no provision to prevent soil erosion.

q) Forest product means timber, pulpwood, firewood, bark, tree top, resin, gum, wood, oil, honey, beeswax, nipa, rattan, or other forest growth such as grass, shrub, and flowering plant, the associated water, fish, game, scenic, historical, recreational and geologic resources in forest lands.

r) Dipterocarp forest is a forest dominated by trees of the dipterocarp species, such as red lauan, tangile, tiaong, white lauan, almon, bagtikan and mayapis of the Philippine mahogany group, apitong and the yakals.

s) Pine forest is a forest composed of the Benguet Pine in the Mountain Provinces or the Mindoro Pine in Mindoro and Zambales provinces.

t) Industrial plantation is any tract of forest land purposely and extensively planted to timber crops primarily to supply the raw material requirements of existing or proposed processing plants and related industries.

u) Tree farm refers to any tract of forest land purposely and extensively planted to trees of economic value for their fruits, flowers, leaves, barks, or extracts, but not for the wood thereof.

v) Multiple-use is the harmonized utilization of the numerous beneficial uses of the land, soil, water, wildlife, recreation value, grass and timber of forest lands.

w) Selective logging means the systematic removal of the mature, over-mature and defective trees in such manner as to leave adequate number and volume of healthy residual trees of the desired species necessary to assure a future crop of timber, and forest cover for the protection and conservation of soil and water.

x) Seed tree system is partial clearcutting with seed trees left to regenerate the area.

y) Healthy residual is a sound or slightly injured tree of the commercial species left after logging.

z) Sustained-yield management implies continuous or periodic production of forest products in a working unit with the aid of achieving at the earliest practicable time an approximate balance between growth and harvest or use. This is generally applied to the commercial timber resources and is also applicable to the water, grass, wildlife, and other renewable resources of the forest.

aa) Processing plant is any mechanical set-up machine or combination of machine used for the processing of logs and other forest raw materials into lumber, veneer, plywood, wallboard, blockboard, paperboard, pulp, paper or other finished wood products.

bb) Lease is a privilege granted by the State to a person to occupy and possess in consideration of a specified rental, any forest land of the public domain in order to undertake any authorized activity therein.

cc) License is a privilege granted by the State to a person to utilize forest resources as in any forest land, without any right of occupation and possession over the same, to the exclusion of others, or establish and operate a wood-processing plant, or conduct any activity involving the utilization of any forest resources.

dd) License agreement is a privilege granted by the State to a person to utilize forest resources within any forest land with the right of possession and occupation thereof to the exclusion of others, except the government, but with the corresponding obligation to develop, protect and rehabilitate the same in accordance with the terms and conditions set forth in said agreement.

ee) Permit is a short-term privilege or authority granted by the State to a person to utilize any limited forest resources or undertake a limited activity with any forest land without any right of occupation and possession therein.

ff) Annual allowable cut is the volume of materials whether of wood or other forest products, that is authorized to be cut regularly from the forest.

gg) Cutting cycle is the number of years between major harvests in the same working unit and/or region, within a rotation.

hh) Ecosystem means the ecological community considered together with non-living factors and its environment as a unit.

ii) Silviculture is the establishment, development, reproduction and care of forest trees.

jj) Rationalization is the organization of a business or industry using scientific business management principles and simplified procedures to obtain greater efficiency of operation.

kk) Forest officer means any official or employee of the Bureau who, by the nature of his appointment or the function of the position to which he is appointed, is delegated by law or by competent authority to execute, implement or enforce the provisions of this Code, other related laws, as well as their implementing regulations.

ll) Primitive tribe is a group of endemic tribe living primitively as a distinct portion of a people from a common ancestor.

mm) Private right means or refers to titled rights of ownership under existing laws, and in the case of primitive tribes, to rights of possession existing at the time a license is granted under this Code, which possession may include places of abode and worship, burial grounds, and old clearings, but excludes production forest inclusive of logged-over areas, commercial forests and established plantations of forest trees and trees of economic value.

nn) Person includes natural as well as juridical person.

## CHAPTER I

### ORGANIZATION AND JURISDICTION OF THE BUREAU

SEC. 4. Creation of, and merger of all forestry agencies into, the Bureau of Forest Development. - For the purpose of implementing the provisions of this Code, the Bureau of Forestry, the Reforestation Administration, the Southern Cebu Reforestation Development Project, and the Parks and Wildlife Office, including applicable appropriations, records, equipment, property and such personnel as may be necessary are hereby merged into a single agency to be known as the Bureau of Forest Development, hereinafter referred to as the Bureau.

SEC. 5. Jurisdiction of Bureau. - The Bureau shall have jurisdiction and authority over all forest land, grazing lands, and all forest reservations including watershed reservations presently administered by other government agencies or instrumentalities.

It shall be responsible for the protection, development, management, regeneration, and reforestation of forest

SEC. 30. Rationalization of the wood industry. - While establishment of wood processing plants shall be encouraged, their locations and operations shall be regulated in order to rationalize the industry. No new processing plant shall be established unless adequate raw material is available on a sustained-yield basis in the area where the raw materials will come from.

The Department Head may cancel, suspend, or phase out all uneconomical wood-processing plants which are not responsive to the rationalization program of the government.

SEC. 31. Wood wastes, weed trees and residues. - Timber licensees shall be encouraged and assisted to gather and save the wood wastes and weed trees in their concessions, and those with processing plants, the wood residues thereof, for utilization and conversion into wood by-products and derivatives.

SEC. 32. Log production and processing. - Unless otherwise decreed by the President, upon recommendation of the National Economic Development Authority, the entire production of logs by all licensees shall, beginning January 1, 1976, be processed locally.

A licensee who has no processing plant may, subject to the approval of the Director, enter into a contract with a wood processor for the processing of his logs. Wood processors shall accept for processing only logs cut by, or purchased from, licensees of good standing at the time of the cutting of logs.

#### C. REFORESTATION

SEC. 33. Forest lands to be reforested. - The following shall be reforested and covered with suitable and sufficient trees, to wit:

a) Bare or grass-covered tracts of forest lands with at least fifty per cent (50%) slope;

b) Bare or grass-covered tracts of forest lands with less than fifty per cent (50%) slope, but with soil so highly erodible as to make grass cover inadequate for soil erosion control;



c) Brushlands or tracts of forest lands generally covered with brush; which need to be developed to increase their productivity;

d) Open tracts of forest lands with slopes or gradients generally exceeding fifty (50%) per cent, interspersed with patches of forest, each of which is less than two hundred fifty (250) hectares in area;

e) Denuded or inadequately-timbered areas proclaimed by the President as forest reserves and reservations as critical watersheds, national parks, game refuge, bird sanctuaries, national shrines, national historic sites;

f) Inadequately-stocked forest lands within forest concessions;

g) Portions of areas covered by pasture leases or permits having a slope of at least fifty (50%) per cent; and

h) River banks, easements, road rights of ways, deltas, swamps, former river beds, and beaches.

SEC. 34. Industrial Tree Plantations and Tree Farms. - A lease for a period of twenty-five (25) years, renewable for another period not exceeding twenty-five (25) years, for the establishment of an industrial tree plantation or a tree farm may be granted by the Department Head upon recommendation of the Director to any person qualified to develop and exploit natural resources, over timber or forest lands of the public domain categorized in Section 33 hereof, with a minimum area of One Thousand (1,000) hectares for industrial tree plantation and One Hundred (100) hectares for tree farm; Provided, that the size of the area that may be granted under each category shall in each case depend upon the capacity of the lessee to develop or convert the area into productive condition within the term of the lease; Provided, further, that no lease shall be granted within watersheds.

Scattered areas of less than One Hundred (100) hectares each may be leased for the establishment of tree farms to different qualified persons upon a showing that if developed as an integrated unit these areas can be economically exploited; Provided, That it shall be a condition of the lease that such persons organize themselves into a cooperative to ensure the orderly management thereof.

The lease may be granted under such terms and conditions as the Department Head may prescribe, taking into account, among others, the raw material needs of forest-based industries and the maintenance of a wholesome ecological balance.

Reforestation projects of the Government, or portions thereof which, upon field evaluation, are found to be more suitable for, or can be better developed as, industrial tree plantations or tree farms in terms of benefits to the Government and the general surrounding area, may be the subject of the lease under this section.

SEC. 35. Priority. - Over any suitable area covered by a timber license agreement, or a pasture lease agreement or permit, the priority to establish industrial forest plantation or tree farm shall be given to the holder thereof.

The priority herein granted must, however, be availed of within a reasonable period to be determined by the Department Head, otherwise, the area shall be declared open to any qualified person and consequently segregated from the holder's area.

SEC. 36. Incentives. - To encourage qualified persons to engage in industrial tree plantation and/or tree farming, the following incentives are granted:

a) Payment of a nominal filing fee of fifty centavos (₱0.50) per hectare;

b) No rental shall be collected during the first five (5) years from the date of the lease; from the sixth year to the tenth year, the annual rental shall be fifty (₱0.50) centavos per hectare; and thereafter, the annual rental shall be one peso (₱1.00) per hectare: Provided, That lessees of areas long denuded as certified by the Director and approved by the Department Head, shall be exempted from the payment of the rental for the full term of the lease which shall not exceed twenty-five (25) years; for the first five (5) years following the renewal of the lease, the annual rental shall be fifty centavos (₱0.50) per hectare; and thereafter, the annual rental shall be one peso (₱1.00) per hectare.

c) The lessee shall pay forest charges on the timber and other forest products grown and cut or

gathered in an industrial tree plantation or tree farm equivalent to six percent (6%) current market value thereof.

d) Sale at cost of seedlings and free technical advice and assistance to persons who will develop their privately-owned lands into industrial tree plantation or tree farm;

e) Exemption from the payment of the percentage tax levied in Title V of the National Internal Revenue Code when the timber and forest products are sold, bartered or exchanged by the lessee whether in their original state or not;

f) The Board of Investments shall, notwithstanding its nationality requirement on projects involving natural resources, classify industrial tree plantations and tree farms as pioneer areas of investment under its annual priority plan, to be governed by the rules and regulations of said Board. A lessee of an industrial tree plantation or tree farm may either supply to the Board of Investments for the tax and other benefits thereunder, or avail of the following benefits:

1. Amounts expended by a lessee in the development and operation of an industrial tree plantation or tree farm prior to the time when the production state is reached; may, at the option of said lessee, be regarded as ordinary and necessary business expenses or as capital expenditures; and
2. Deduction from an investor's taxable income for the year, of an annual investment allowance equivalent to thirty-three and one-third percent (33-1/3%) of his actual investment during the year in an enterprise engaged in industrial tree plantation or tree farm; Provided, That such investment shall not be withdrawn for a period of at least ten (10) years from the date of investment; Provided, further, That should the investment be withdrawn within such period, a tax equivalent to double the amount of the total income tax rebate resulting from the investment allowance shall be payable as a lump sum in addition to the income tax due from the taxpayer for the year the investment was withdrawn.

g) Except when public interest demands the alteration or modification, the boundaries of an area covered by an industrial tree plantation or tree farm lease, once established on the ground, shall not be altered or modified; and

h) A lessee shall not be subject to any obligation prescribed in, or arising out of, the provisions of the National Internal Revenue Code on withholding of tax at source upon interests paid or borrowings incurred for development and operation of the industrial tree plantation or tree farm.

The Department Head may provide other incentives in addition to those hereinabove granted to promote industrial tree plantation and tree farms in special areas such as, but not limited to, those where there are no roads or where roads are inadequate, or areas with rough topography and remote areas far from processing plants.

All amounts collected under this section shall accrue to a special deposit of the Bureau to be used for reforestation of critical watersheds or degraded areas and other development activities, over and above the general appropriation of the said Bureau.

#### D. FOREST PROTECTION

SEC. 37. Protection of all resources. - All measures shall be taken to protect the forest resources from destruction, impairment and depletion.

SEC. 38. Control of concession area. - In order to achieve the effective protection of the forest lands and the resources thereof from illegal entry, unlawful occupation, kaingin, fire, insect infestation, theft, and other forms of forest destruction, the utilization of timber therein shall not be allowed except through license agreements under which the holders thereof shall have the exclusive privilege to cut all the allowable harvestable timber in their respective concessions, and the additional right of occupation, possession, and control over the same, to the exclusive of all others, except the government, but with the corresponding obligation to adopt all the protection and conservation measures to ensure the continuity of the productive condition of said areas, conformably with multiple use and sustained yield management.

MALAKANANG  
Manila

PRESIDENTIAL DECREE NO. 1559

FURTHER AMENDING PRESIDENTIAL DECREE NO. 705, OTHERWISE  
KNOWN AS THE "REVISED FORESTRY CODE OF THE  
PHILIPPINES."

WHEREAS, there is need to further strengthen the Code to make it more responsive to present realities and to the new thrust of government policies and programs on forest development and conservation and rationalization of the wood industry;

WHEREAS, forest development and wood industry programs should complement, as well as enhance, the rural development program of the government; and

WHEREAS, there is a need to provide sufficient incentives to encourage and further expand the participation of the private sector in forest management, protection and development as well as in wood processing activities within the concept of joint or co-management of the forest resources;

NOW, THEREFORE, I, FERDINAND E. MARCOS, President of the Philippines, by virtue of the powers vested in me by the Constitution, do hereby amend Presidential Decree No. 705 as follows:

SECTION 1. Sections 3, 11, 14, 17, 19, 20, 22, 26 and 30 of the said Decree are amended as follows:

"SEC. 3. Definitions -

"a) Public forest is a mass of land of the public domain which has not been subject to the present system of classification for the determination of which lands are needed for forest purposes and which are not.

"b) Permanent forest or forest reserves refers to those lands of the public domain which have been the subject of the present system of classification and declared as needed for forest purposes.

"c) Alienable or disposable lands refer to those lands of the public Domain which have been the subject of the present system of classification and declared as not needed for forest purposes.

"d) Forest lands includes the public forest, the permanent forest or forest reserves, and forest reservations.

"e) Grazing land refers to that portion of the public domain which has been set aside, in view of the suitability of its topography and vegetation, for the raising of livestock.

"f) Mineral lands refer to those lands of the public domain which have been classified as such by the Secretary of Natural Resources in accordance with prescribed and approved criteria, guidelines and procedure.

"g) Forest reservations refer to forest lands which have been reserved by the President of the Philippines for any specific purpose or purposes.

"h) National park refers to a forest land reservation essentially of primitive or wilderness character which has been withdrawn from settlement or occupancy and set aside as such exclusively to preserve the scenery, the natural and historic objects and the wild animals or plants therein, and to provide enjoyment of these features in such a manner as will leave them unimpaired for future generations.

"i) Game refuge or bird sanctuary refers to a forest land designated for the protection of game animals, birds and fish and closed to hunting and fishing in order that the excess population may flow and restock surrounding areas.

"j) Marine park refers to any public offshore area delimited as habitat or rare and unique species of marine flora and fauna.

"k) Seashore park refers to any public shore area delimited for outdoor recreation, sports fishing, water skiing and related healthful activities.

"l) Watershed reservation in a forest land reservation established to protect or improve the conditions of the water yield thereof or reduce sedimentation.

"m) Watershed is a land area drained by a stream or fixed body of water and its tributaries having a common outlet for surface run-off.

"n) Critical watershed is a drainage area of a river system supporting existing and proposed hydro-electric power, irrigation works or domestic water facilities needing immediate protection or rehabilitation.

"o) Mangrove is a term applied to the type of forest occurring on tidal flat along the sea coast, extending along stream where the water is brackish.

"p) Kaingin refers to a portion of the forest land which is subjected to shifting and/or permanent slash-and-burn cultivation.

"q) Forest product means timber, pulpwood, firewood, bark, tree top, resin, gum, wood, oil, honey, beeswax, nipa, rattan, or other forest growth such as grass, shrub, and flowering plant, the associated water, fish, game, scenic, historical, recreational and geologic resources in forest lands.

"r) Dipterocarp forest is a forest dominated by trees of the dipterocarp species, such as red lauan, tanguile, tiaong, white lauan, almon, bagtikan and mayapis of the Philippine mahogany group, apitong and the yakals.

"s) Pine forest is a forest type predominantly of pine trees.

"t) Industrial tree plantation refers to any forest land extensively planted to tree crops primarily to supply raw material requirements of existing or proposed wood processing plants and related industries.

"u) Tree farm refers to any small forest land or tract of land purposely planted to tree crops.

"v) Agro-forestry is a sustainable management for land which increases overall production, combines agricultural crops, tree crops and forest plants and/or animals simultaneously or sequentially, and applies management practices which are compatible with the cultural patterns of the local population.

"w) Multiple-use is the harmonized utilization of the land, soil, water, wildlife, recreation value, grass and timber of forest lands.

"x) Selective logging is the systematic removal of the mature, over-mature and defective trees in such manner as to leave adequate number and volume of healthy residual trees of the desired species necessary to assure a future crop of timber, and forest cover for the protection and conservation of soil, water and wildlife.

"y) Seed tree system is a silvicultural system characterized by partial clear-cutting leaving seed-trees to regenerate the area.

"z) Healthy residual refers to a sound or slightly injured tree of the commercial species left after logging.

"aa) Sustained-yield management implies continuous or periodic production of forest products in a working unit for the purpose of achieving at the earliest practicable time an approximate balance between growth and harvest or use. This is generally applied to the commercial timber resources and is also applicable to the water, grass, wildlife, and other renewable resources of the forest.

"bb) Processing plant is any mechanical set-up, device, machine or combination of machines used for the conversion of logs and other forest raw materials into lumber, veneer, plywood, fiberboard, blockboard, paper board, pulp, paper or other finished wood products.

"cc) Lease is a privilege granted by the State to a person to occupy and possess, in consideration of specified rental, any forest land of the public domain in order to undertake any authorized activity therein.

"dd) License is a privilege granted by the State to a person to utilize forest resources within any forest land, without any right of occupation and possession over the same, to the exclusion of others, or establish and operate a wood-processing plant, or conduct any activity involving the utilization of any forest resources.

"ee) License agreement is a privilege granted by the State to a person to utilize forest resources within any forest land with the right of possession and occupation thereof to the exclusion of others, except the government, but with the corresponding obligation to develop, protect and rehabilitate the same in accordance with the terms and conditions set forth in said agreement.

"ff) Permit is a short-term privilege or authority granted by the State to a person to utilize any limited forest resources or undertake a limited activity within any forest land without any right of occupation and possession therein.

"gg) Annual allowable cut is the volume of materials, whether of wood or other forest products, that is authorized to be cut yearly from a forest.

"hh) Cutting cycle is the number of years between two major harvests in the same working unit and/or region.

"ii) Forest ecosystem refers to the living and non-living components of a forest and their interaction.

"jj) Silviculture is the establishment, development, reproduction and care of forest trees.



"kk) Rationalization is the organization of a business or industry using management principles, systems and procedures to attain stability, efficiency and profitability of operation.

"ll) Forest officer means any officials or employee of the Bureau who has been appointed or delegated by law or by competent authority to execute, implement or enforce the provisions of this Code, other related laws, as well as their implementing regulations.

"mm) Private right means or refers to titled rights of ownership under existing law, and in the case of national minority to rights of possession existing at the time a license is granted under this Code, which possession may include places of abode and worship, burial grounds, and old clearings, but exclude productive forest inclusive of logged-over areas, commercial forest and established plantations of forest trees and trees of economic values.

"nn) Person includes natural as well as juridical person."

"SEC. 11. Manpower and policy development. - The Bureau shall establish and operate an in-service training center for the purpose of upgrading and training its personnel and new employees.

"The Bureau shall also set aside adequate funds to enable personnel to obtain specialized education and training in local or foreign colleges or institutions.

"There shall be established in the College of Forestry, University of the Philippines at Los Baños, in coordination with the Department of Natural Resources and the wood industry, a Forestry Development Center which shall conduct basic policy researches in forestry and develop or help develop an effective machinery for forestry policy formulation and implementation. To help defray the cost of operating said Center, it is authorized to receive assistance from the wood industry and other sources."

"SEC. 14. Existing pasture leases in forest lands. - Forest lands which are not reservations and which are the subject of pasture leases shall be classified as grazing lands and areas covered by pasture permits shall remain forest lands until otherwise classified under the criteria, guidelines and methods classification to be prescribed by the Department Head: Provided, That the administration, management and disposition of grazing lands shall remain under the Bureau."

" SEC. 17. Establishment of boundaries of forest lands. - All boundaries between permanent forests and alienable or disposable lands shall be clearly marked and maintained on the ground, with infrastructure or roads, or concrete monuments at intervals of not more than five hundred (500) meters in accordance with established procedures and standards, or any other visible and practicable signs to insure protection of the forest.

"In all cases of boundary conflicts, reference shall be made to the Philippine Coast and Geodetic Survey Topo map."

"SEC. 19. Multiple use. - The numerous beneficial uses of the timber, land, soil, water, wildlife, grass and recreation or aesthetic value of forest lands and grazing lands shall be evaluated and weighted before allowing their utilization, exploitation, occupation or possession thereof, or the conduct of any activity therein.

"Only the utilization, exploitation, occupation or possession of any forest lands and grazing lands, or any activity therein, involving one or more of its resources, which will produce the optimum benefits to the development and progress of the country and the public welfare, without impairment or with the injury to its resources, shall be allowed.

"All forest reservations may be open to development or uses not inconsistent with the principal objectives of the reservation: Provided, That critical watersheds, national parks and established experimental forests shall not be subject to commercial logging or grazing operations, and game refuges, bird sanctuaries, marine and seashore parks shall not be subject to hunting or fishing and other activities of commercial nature."

" SEC. 20. License agreement, license, lease or permit. - No person may utilize, exploit, occupy, possess or conduct any activity within any forest and grazing land, or establish, install, add and operate any wood or forest products processing plant, unless he had been authorized to do under a license agreement, license, lease or permit: Provided, That when the national interest so requires, the President may amend, modify, replace, or rescind any contract, concession, permit, license, or any other form of privilege granted herein: Provided further, That upon the recommendation of the appropriate government agency, the President may, pending the conduct of appropriate hearing, order the summary suspension of any such contract, concession, license, permit, lease or privilege granted under this decree for violation of any of the condition therein such as those pertaining but

not limited to reforestation, pollution, environmental protection, export limitation or such condition as are prescribed by the Minister of Natural Resources in daily issued regulations.

"SEC. 22. Silvicultural and harvesting system. - In any logging operation in production forests within forest lands, the proper silvicultural and harvesting system that will promote optimum sustained yield shall be practiced, to wit:

"a) For dipterocarp forest, selective logging with enrichment or supplemental planting when necessary.

"b) For pine or mangrove forest, the seed tree system with planting when necessary.

Provided, That subject to the approval of the Department Head, upon recommendation of the Director, any silvicultural and harvesting system that may be found suitable as a result of research may be adopted: Provided further, That no authorized person shall cut, harvest or gather any timber, pulpwood, or other products of logging unless he plants three times of the same variety for every tree cut or destroyed by such logging or removal of logs. Any violation of this provision shall be sufficient ground for the immediate cancellation of the license, agreement, lease of permit.

"SEC. 26. Annual allowable cut. - The annual allowable cut or harvest of any particular forest land under a license agreement, license, lease or permit shall be determined on the basis of the size of the area, the volume and kind of harvestable timber or forest products and healthy residuals, seed trees and reproduction found therein, and the established cutting cycle and rotation thereof.

"No person shall cut, harvest and gather any particular timber, pulpwood, firewood and other forest products unless he has been authorized under Section 20 hereof to do so and the particular annual allowable cut thereof has been granted.

"In the public interest and in accordance with Section 21 hereof, the Department Head shall review all existing annual allowable cut and thereupon shall rescribe the level of annual allowable cut for the common dipterocarp timber, softwood and hardwood timber cutting of which is not prohibited, pulpwood, firewood and other forest products using as bases the factors as well as the updated aerial photographs and field inventories of such forest land: Provided, That pending the completion of such review and appropriate amendment of the annual allowable cut in existing license agreement, license, lease or permit,

existing annual allowable cut that not sufficiently supports wood or forest products processing plant or that will support duly approved processing expansion program or new processing projects may be allowed to continue without change: Provided further, That no additional or adjustment in annual allowable cut shall be made until after such a review has been made."

"SEC. 30. Rationalization of the wood and forest products industry. - While the expansion and integration of existing wood or forest products processing plants, as well as the establishment of new processing plants shall be encouraged, their locations and operations shall be regulated in order to rationalize the whole industry.

"No expansion or integration of existing processing plant nor establishment of new processing plant shall be allowed unless environmental consideration are taken into account and adequate raw material supply on a sustained-yield basis is assured.

"A long-term assurance of raw material source from forest concessions and/or from industrial tree plantations, tree farms or agro-forest farms whose annual allowable cut and/or whose harvest is deemed sufficient to meet the requirement of such processing plant shall govern, among others, the grant of the privilege to establish, install additional capacity or operate a processing plant.

"Henceforth within one year from the date of this law, as a condition to exercise of the privileges granted them under a license agreement, license, lease or permit, wood or forest products processors without forest concessions or areas that may be developed into industrial tree plantations, tree farms or agro-forest farms and licensees, lessees or permittees without processing plants shall jointly adopt any feasible scheme or schemes, other than log supply contract, for the approval of the Department Head: Provided, That no license agreement, license, lease or permit, including processing plant permit, shall be granted or renewed unless said scheme or schemes are submitted to, and approved by, the Department Head.

"All processing plants existing, to be expanded, to be integrated or to be established shall obtain operating permits, licenses and/or approval from the Bureau or the Department, as the case maybe, and shall submit themselves to other regulations related to their operation.

"The Department Head may cancel, suspend, or phase out all inefficient, wasteful, uneconomical or perennially short in raw material wood or forest products processing plants which are not responsive to the rationalization program of the government."

SEC. 2. Section 32 as amended by Presidential Decree No. 865, is further amended to read as follows:

"SEC. 32. Log production and processing. - Unless otherwise directed by the President, upon recommendation of the Department Head, the entire production of logs by all timber licensees shall, beginning January 1, 1976 be processed locally: Provided, That the following conditions must be complied with by those who apply to be allowed to export a portion of their log production to be determined by the Department Head such that the total log export of these timber licensees shall not exceed twenty-five percent (25%) of the total national allowable cut:

- "1) Timber licensees with existing viable processing plants or
- "2) Timber licensees with processing projects duly approved by the Department Head or
- "3) Timber licensees who have acquired viable processing machinery and equipment which will be installed and will become operational in accordance with the schedule approved by the Department Head; and
- "4) Timber licensees whose log export support or are in line with, government-approved trade agreement:

Provided, further, That no person shall be given a permit to export if he has not complied with the requirements on replanting and reforestation. Provided, That the President may, upon recommendation of the Department Head, whenever the export price of logs falls to unreasonably low level or whenever public interest so requires, cancel log exportation or reduce the maximum allowable proportion for log exports.