CHAPTER I

INTRODUCTION

1.1 Introduction

Coconut shells grows well in hot zones where there is plentiful and regular rainfall throughout the year, the southern part of Thailand is deal for it. It is grown mostly in the provinces of Krabi, Surat Thani, Chumphon and Satun. The plantation areas in provinces account for about 95% of coconut shells growing area in Thailand. Other provinces where it is widely planted are Trang, Prachuab Khiri Khun, Phuket and Yala [1]. Figure 1.1 shows coconut tree.

Coconut cultivation in Thailand has shown increasing economic significance with its expanding market demand at an average growth rate of 15 % a year[2]. Estimates of the Bank of Thailand put coconut shell plantation areas in Thailand, mainly concentrated in the southern part of Thailand. The market study revealed that coconut shells production in Thailand during 1997[3] was about 449,796 tons/year. In 1998, it estimated that about 474,402 tons or 36,707 tons/month. Over the remainder was used in various industries, ie., waste water treatment, confectionery, margarine and shortening. Expansion of the coconut shells industry was followed by the generation of enormous amounts of by-products at plantation grounds and refineries. It has been estimated that the pressing process produces about 292,367 tons and 742,163 tons of empty fruit bunches as waste in 1997.

Figure 1.1 Coconut tree.

1.2 Activated carbon

Activated carbon has been in use for thousands of year. The major development of activated carbon began during World War I, when hard granular activated carbon (GAC) was manufactured for use in gas masks. In the last 50 years the technology involved in activated carbon manufacture has advanced. Powdered activated carbon (PAC) is extensively used in water purification processes together with granulated activated carbon. PAC is associated with larger pore diameters than GAC.

Activated carbon is widely used as adsorbents in gas and liquid-phase separation processes, purification of products and water cleaning operations. One of the most important fields in terms of consumption is in water and wastewater treatment, where activated carbon with a relatively high surface area and a well developed porosity is needed. Uses of activated carbon[4] are shown in Figure 1.2. To obtain activated carbon from cheap and readily available precursors become an interesting objective. Quantity and value of import and export of activated carbon in Thailand between 1988-1999 are shown in Table 1.1.

Table 1.1 Quantity and value of import and export of activated carbon between 1988-1999 (Activated carbon code 3802.100-004)[5]

Year	Import		Export	
	Quantity(kg)	Value(baht)	Quantity(kg)	Value(baht)
1988	1,932,203	52,327,284	260,802	8,118,737
1989	2,649,582	72,244,916	378,375	13,348,250
1990	2,321,914	75,358,548	663,917	25,001,383
1991	2,641,830	77,949,916	1,056,294	36,448,330
1992	2,706,967	101,418,463	1,027,131	34,008,219
1993	2,908,243	96,311,517	478,921	15,885,489
1994	2,816,400	103,186,178	522,068	18,246,436
1995	2,883,399	124,605,555	1,764,739	48,257,484
1996	3,047,195	100,836,897	2,937,245	75,682,676
1997	3,598,415	127,139,283	2,807,200	99,373,426
1998	3,141,000	114,681,336	2,736.400	120,315,042
1999	2,891,000	99,498,333	315,675	11,521,003

Source: Department of Business Economic, Finance Ministry.

The world annual production of activated carbon in all forms is estimated to be in the range of 300,000-400,000 tones. About 55% of this total was in powder form, about 35% in granular form and the remainder is produced as pellets or extradites, according to a reference[6], about 80% of the total production (power, granular and formed carbon) is used in liquid-phase applications and the remaining 20% (granular and formed carbon only) in gas-phase applications. The highest consumption in Japan and the USA per capita annual consumption is 0.5 kg in Japan, 0.4 kg in the USA in Europe and 0.03 kg in the rest of the world.

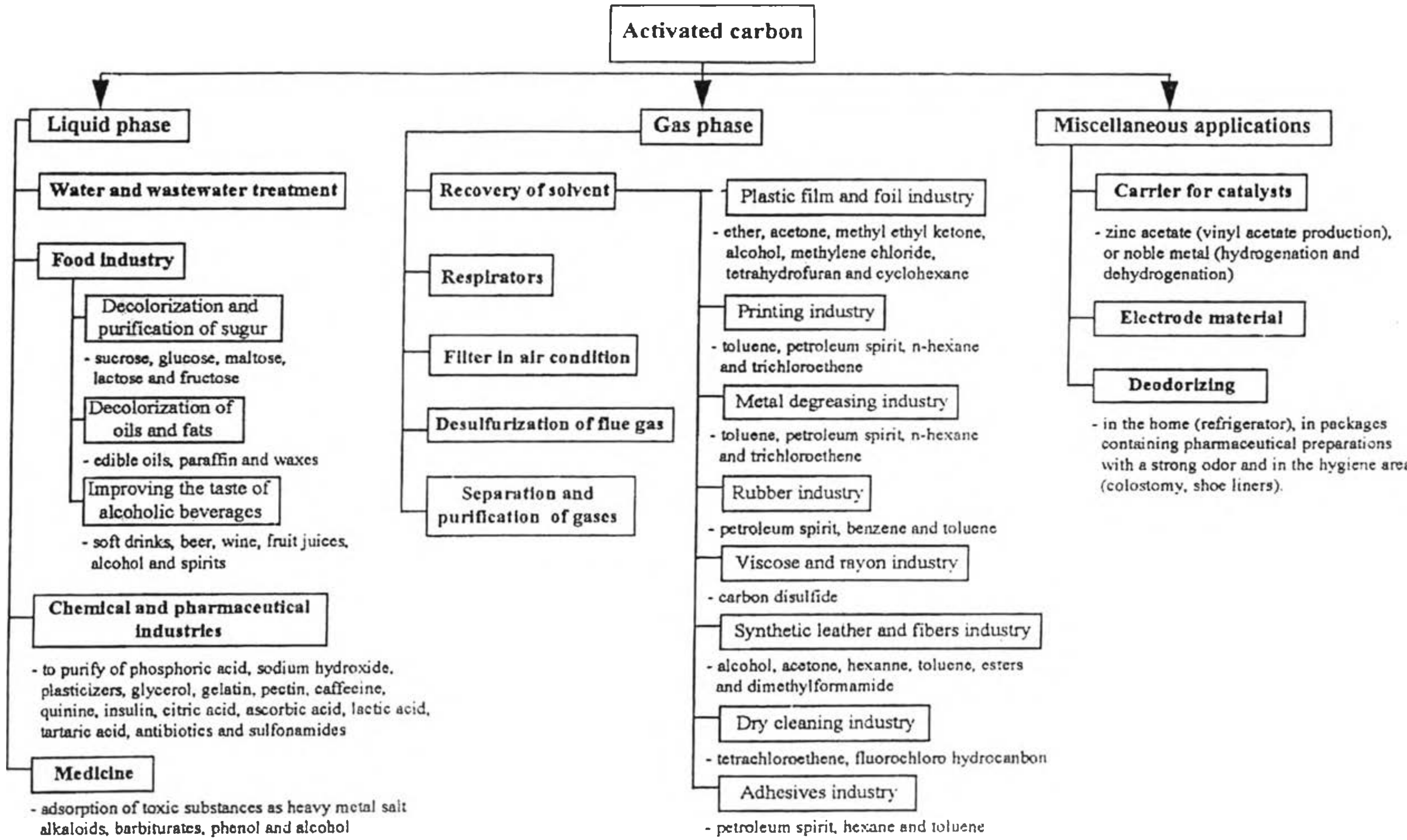

Figure 1.2 Uses of activated carbon[4].

Consumption is increasing at a reported rate of about 7% per annual[3]. Growth areas are in air purification, solvent recovery and groundwater treatment and new applications are emerging, particularly those related to environment protection, that will tend to sustain the level of demand. The approximate average selling price for granular or formed carbon is between US$ 1,500-4,000 per ton. For powder carbon, it is between US$ 500-1,200 per ton. The actual price will vary with the level of activity (surface areas commonly fall in the range 800-1,500 m^2/g^{-1}), the strength and attrition resistance if impregnates have been added to enhance adsorption selectivity[3].

Coconut shells-based activated carbon is prepared from raw coconut shells by carbonization followed by steam activation. Carbonization involves heating to a high temperature in an inert atmosphere. Activation involves reaction with steam under carefully controlled conditions to develop specific pore structures and adsorptive properties. Steam activation at 800-900 ^0C produce carbons with internal surface areas ranging from 900 to 1,500 m^2/g carbon. Coconut shells is used in producing activated carbon because they have the following advantages over many other types of carbon:

- High hardness level and low dust level. This improves material handling characteristics and is especially important where carbon fines cannot be tolerated.
- High surface area, up to 1,500 m^2/g. This allows for long life and high adsorption capacity.
- High retentively, preventing unwanted desorption of adsorbed species.
- Large fraction of micropores (<20 Angstroms). This is important for removal of low-molecular-weight organics and for removal of contaminants.
- Low ash and impurities.

Coconut shells activated carbons are ideal for gas-phase applications and for liquid-phase applications where purification to trace concentrations is required. Examples of liquid-phase applications include gold recovery and high efficiency water purification. They produced a wide range of coconut shells activated carbon for water purification application. Because of their low dust, low ash characteristics, coconut carbon is especially effective in removing trace organic compound.

Commercial processes to produce activated carbon used a variety of raw materials including peat, coal, and wood and coconut shell. Among these, coconut shells is the interesting raw material because of its enormous amounts as by-products in coconut shells industrial. From proximate analysis, it was observed that coconut shells have properties similar to palm-oil shells but palm-oil shells have more ash than coconut shells, so coconut shells are likely to be a precursor for the production of activated carbon. The proximate analysis and the B.E.T. surface area compared with coconut shells and palm-oil shells are shown in Table 1.2.

Table 1.2 The proximate analysis and the B.E.T. surface of coconut shells and palm-oil shells.

Raw material	%VM	%Ash	%FC	IA (mg/g)	MB (mg/g)	Surface area(m^2/g)		
						S_{total}	S_{Micro}	$S_{External}$
Coconut shells	80.82	0.40	18.80	97.6	5.0	0.9	0.0	0.9
Palm-oil shells	79.66	2.05	18.29	-	-	12.2	0.0	12.2

1.3 Objectives

This work is to study optimum condition in the production of activated carbon from coconut shells by carbonization and steam and CO_2 activation in a activator, which reducing problem from by-product in coconut shells industry and a better solution from an environmental and economic standpoint. The objectives of this work are following:

1. To find effective parameters and optimum conditions for the production of activated carbon by pyrolysis and steam activation in a fixed bed reactor.
2. To study physical properties of the products.

1.4 Scope of the research

For the production of activated carbon from coconut shells by carbonizing and activation, the appropriate condition such as temperatures, times, sizes of the raw material, flow rates of air, CO_2 and superheated steam before activation were studied. The necessary procedures are following:

1. Literature survey and in-depth study of this research work.
2. Carbonization of Para wood crushed and sieved to three different particle sizes of 0.33-0.60, 0.60 – 1.18, 1.18 - 2.36 and 2.36 - 4.75 mm.
3. Proximate analysis of coconut shells.
4. Production of activated carbon from coconut shells by pyrolysis by changing the following parameters so as to attain the optimum condition:
   (a) The optimum temperature and time
   (b) The optimum size of coconut shells
   (c) The optimum flow rate of air, CO_2 and superheated steam
5. Investigation of the properties of the activated carbon such as % yield, % ash, bulk density, iodine number, methylene blue number and B.E.T. surface area.
6. Summarizing the results.