CHAPTER VII

COST ANALYSIS OF RICE HUSK SILICA AND RH-MCM-41

7.1 Introduction

According to all previous chapters, a life cycle of the synthesized MCM-41 was introduced and ended up with the treatment of chlorinated substances. The success in the utilization of rice husk waste as a raw material for MCM-41 synthesis and the application of synthesized MCM-41 for the treatment of chloroform were apparently aware in environmental aspect. Not only were the satisfied results from the experiments expected, but the feasibility in an economic advance was also considered. Cost analysis is an important parameter in order to determine whether the alternative utilization of rice husk proposed in this study is effective and practical for scale up or not. In this chapter, the estimated costs of the MCM-41 material retrieved from various sources of silica such as tetraethylorthosilicate (TEOS), rice husk (RH) and rice husk ash (RHA) were economically computed and assessed in comparison with other commercial porous materials: silica and zeolite.

7.2 Analysis of Economic Cost for MCM-41 Synthesis

Following our experiment, there were two steps to produce RH-MCM-41. Figure 7-1 shows the summary of the chemicals used in each step. Costs of raw materials and the utilities used for the extraction of rice husk silica were presented in Table 7-1, the synthesis of the parent MCM-41 from TEOS in Table 7-2 and the synthesis of the RH-MCM-41 in Table 7-3. The electricity charges for the electric appliances used in the experiment could be calculated as follows:

Electricity consumed (Unit) = Electric power (kW) x Time used (hr)...........**(7-1)**

Electricity charge (Baht) = Unit x Electricity tariff (Baht unit^{-1}) ....**(7-2)**

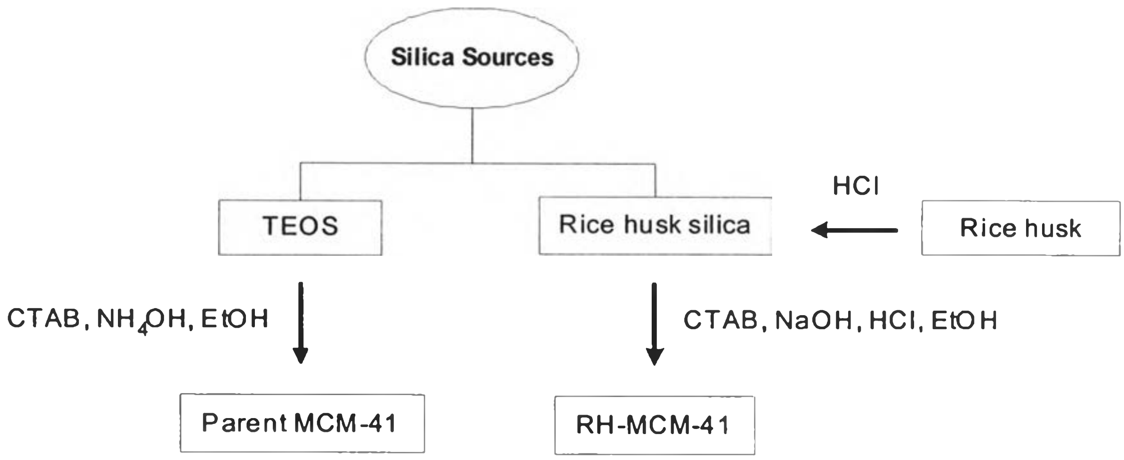

Figure 7-1 Materials used diagram for the synthesis of parent MCM-41 and RH-MCM-41.

Table 7-1 Estimated Cost of 1 g Rice Husk Silica Extracted from Rice Husk.

Material and Utilities	Cost	Amount used	Value (฿)
Rice husk*	0.00 ฿ kg^{-1}	3.00 g	0.00
Rice husk ash**	10.00 ฿ kg^{-1}	3.00 g	0.03
HCl (Lab-Scan)	120.00 ฿ L^{-1}	25.00 mL	3.00
Electricity***	1.97 ฿ $unit^{-1}$		
- Furnace		0.50 units	1.00
Water****	15.81 ฿ m^{-3}	400.00 mL	0.01
		Total	4.01[a], 4.04[b]

Note: * *Obtained free from a waste heap.*

** *85% silica content, International Rice Research Institute (2003).*

*** *According to the electricity tariff applicable to any government institution and agency (69 kV and over), October 2003.*

**** *According to the Water Tariffs for government agency and industry, December 1999.*

[a] *Cost of rice husk silica extracted from raw husk.*

[b] *Cost of rice husk silica extracted from rice husk ash.*

Table 7-2 Estimated cost of 1 g parent MCM-41.

Material and Utilities	Cost	Amount used	Value (฿)
CTAB (Wako Chemical)	11.80 ฿ g^{-1}	1.00 g	11.80
TEOS (Aldrich)	2,288 ฿ L^{-1}	4.17 mL	9.54
NH_4OH (Carlo Erba)	350.00 ฿ L^{-1}	3.33 mL	1.17
Ethanol (Carlo Erba)	230.00 ฿ L^{-1}	30.00 mL	6.90
Deionized water	0.42 ฿ L^{-1}	150.00 mL	0.06
Electricity*	1.97 ฿ $unit^{-1}$		
- Magnetic Stirrer		0.00 unit	0.00
- Suction Pump		0.01 units	0.02
- Furnace		2.68 units	5.28
		Total	34.77

Note: * *According to the electricity tariff applicable to any government institution and agency (69 kV and over), October 2003.*

Table 7-3 Estimated cost of 1 g RH-MCM-41.

Material and Utilities	Cost	Amount used	Value (฿)
CTAB (Wako Chemical)	11.80 ฿ g^{-1}	0.77 g	9.09
Rice husk silica*	4.01[a], 4.04[b] ฿ g^{-1}	1.11 g	4.45[a], 4.48[b]
NaOH (Lab-Scan)	220.00 ฿ kg^{-1}	0.81 g	0.18
HCl (Lab-Scan)	120.00 ฿ L^{-1}	0.00**	0.00**
Ethanol (Carlo Erba)	230.00 ฿ L^{-1}	30.00 mL	6.90
Deionized water	0.42 ฿ L^{-1}	150.00 mL	0.06
Electricity***	1.97 ฿ $unit^{-1}$		
- Magnetic Stirrer		0.00 unit	0.00
- Suction Pump		0.01 units	0.02
- Furnace		2.68 units	5.28
		Total	25.98[a], 26.01[b]

Note: * *Silica extracted from raw husk.*

** *Insignificant amount of HCl used for pH adjustment.*

*** *According to the electricity tariff applicable to any government institution and agency (69 kV and over), October 2003.*

[a] *Cost of rice husk silica extracted from raw husk.*

[b] *Cost of rice husk silica extracted from rice husk ash.*

In order to elucidate the advantages of rice husk waste by means of silica extraction, the assessment of economic values for general purposes such as its utilization as animal feed stuff, brick fillers, fertilizer and production of electricity was shown in Table 7-4. Additionally, the cost of the MCM-41 materials retrieved from various silica sources such as TEOS, the extracted rice husk silica and rice husk ash were compared with the cost of various commercial porous materials; silica and zeolite in Table 7-5.

Table 7-4 Values of rice husk waste for the utilization of various purposes.

Utilization of Rice husk	Value (฿ kg^{-1})
Electricity	0.10[a]
Silica source	720.00[b]
General purposes*	0.10[c]

Note: * *Feed stuff, brick filler, fertilizer etc. [TropRice, 2003].*

[a] *National Energy Policy Office, 2003.*

[b] *Based on commercial price 2,160 Baht* kg^{-1} *of* SiO_2 *[Strem Chemicals, Inc., 2003].*

[c] *TropRice, 2003.*

Table 7-5 Comparisons of cost effectiveness of RH-MCM-41 and commercial porous silica-based materials: zeolite and SiO_2.

Materials	Sources of silica	Cost (฿ kg^{-1})
MCM-41	TEOS	34,770
MCM-41	Rice husk, 99 % SiO_2*	25,980
MCM-41	Rice husk ash, 85 % SiO_2**	26,010
SiO_2* **	Commercial silica surface area 300 m^2 g^{-1}	2,160
Zeolite A ****	Commercial silica 87 % SiO_2 and 13 % Al_2O_3	19,600

Note: * *Obtained from chapter II.*
** *Reported by the International Rice Research Institute (2003).*
*** *Obtained from Strem Chemicals, Inc. (2003).*
**** *Obtained from Strem Chemicals, Inc. (2003).*

7.3 Discussion

Rice husk waste has been massively disposed from rice mills and seems to be valued as worthless even serving for animal feed stuff and fuel for heat production. However, the husk left also provides the substantial benefit for the purpose of electricity generation [TropRice, 2003]. With the capacity of rice husk production estimated 200-500 tons a day, at least 40% of the capacity could be converted to in-process energy for paddy drying, and approximately 70% of the capacity could be converted to electricity by the conversion of ~ 600 kW ton^{-1} husk [Ramboll, 1999] and providing the economic benefit of approximately 0.17 Baht $(kWhr)^{-1}$ [National Energy Policy Office, 2003]. On a basis of 1 hr-electricity consumed, the value of utilized rice husk (RH) is 0.10 Baht kg^{-1} RH. Comparatively, Table 7-1 shows that by means of silica extraction, 1.0 g of silica could be extracted from 3.0 g of RH or RHA with a value of 0.72 Baht g^{-1} rice husk waste, according to the cost of the commercial silica (2.16 Baht g^{-1} silica). It was apparently found in Table 7-4 that the extraction of silica from rice husk waste gave the highest economic value compared with the values from the production of electricity and its uses in general purposes.

Although the rice husk used in this work was obtained for free, the expense of the silica extraction from rice husk seemed to be more expensive (4.01 Baht g^{-1} silica) compared with that of the commercial silica (2.16 Baht g^{-1} silica). As shown in Table 7-5, the most expensive cost calculated per 1 kg of MCM-41 was from commercial silica in the form of TEOS (34,770 Baht g^{-1}). The cost of MCM-41 from the extracted silica was about 26,000 Baht g^{-1}, but it was still higher than the costs of commercial SiO_2 (2,160 Baht g^{-1}) and zeolite (19,600 Baht g^{-1}). This was due to the small scale set up for the experiment. Based on basic of economics theory, the large-scale production would direct the independent demand and supply toward the equilibrium in marketing system, and the investment costs would eventually lower. In addition to the economic advantages, the efficiency in the application of these materials was also taken into account. As described in Chapter VI, the MCM-41 synthesized from the extracted silica from rice husk showed the best performance in the hydrodechlorination of chloroform. These results indicated that the use of recycled wastes has been accomplished in the environmental applications.

7.4 Summary

This study has proposed a success in the development of a value-adding alternative for rice husk utilization by means of the production of a mesoporous material, MCM-41, with an estimated cost of 26,000 Baht kg^{-1}. The new knowledge attained from the experiment would encourage the start of the commercial production of silica-based material as well as the possibility of its use in waste management practices. In others words, the use of extracted silica from rice husk to synthesize a mesoporous material contributed to the enhancement of the waste value and the effectiveness of current hazardous waste treatment practices.