AJChE 2016, Vol. 16, No. 2, 44 – 49

The Effect of Temperature on Extraction of *Swietenia Mahagoni* by Ultrasound–assisted Extraction (UAE) Method

Ike Dayi Febriana [*,1]
Heri Septya Kusuma [1]
Selfina Gala [1]
Mahfud Mahfud [1]
[1] *Department of Chemical Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia*
[*]*e-mail:* mahfud@chem-eng.its.ac.id

Azo dyes are synthetic organic dyes which have azo group (-N=N-) as chromophore. Waste of azo dyes have not been able to overcome completely so that requires solutions of natural dye. Raw material of natural dye can be obtained from *Swietenia mahagoni*. Natural dye can be extracted by ultrasound-assisted extraction (UAE) method. The pupose of this research is to study the factor that influence UAE. Observed factor is influence of extraction temperature to the yield of natural dye. This research was conducted using ratio of material to solvent of 0.05 g/L with extraction time at 40 minute. Extraction temperature was observed at 30, 40, and 50^{o}C. Ultrasonic wave that used for this research at 40 kHz. The result is increasing temperature will be allow the increasing trend of yield. The result indicate that there is about 9.2748% improvement in the yield of extract due to increasing extraction temperature from 30^{o}C to 50^{o}C.

Keywords : *Swietenia mahagoni*; ultrasound-assisted extraction; extraction; natural dyes

INTRODUCTION

Azo dyes are synthetic organic dyes which have a azo group (-N=N-) as chromophore. Azo dye obtained from Diazotization reaction or coupling reaction. Azo dyes used in the dyeing process of textile material, leather, and food industry. Azo dyes cannot be decomposed under aerobic conditions and its will be reduce to form aromatic amine under anaerobic conditions. Therefore, azo dyes are harmful for the environment and human being (Sivakumar et al., 2011).

Some azo dyes waste treatment methods have been reported to overcome the problems. Bio remediation method and adsorption using adsorbents has been reported respectively by Fu and Viraraghavan (2001) and Crini (2006). However, the waste treatment is not capable of dealing with the azo dyes waste thoroughly. So, the application of azo dyes

in the textile industry need to be diminished. Natural dyes can be used as substitution of azo dyes at industry. Natural dyes are eco–friendly and can be applied for dyeing of fibrous material or food coloration. Original source of natural dyes can be derived from vegetable origin, mineral origin, and animal origin. Natural dyes that derived from vegetable origin are found in the roots, bark, leaves, flowers, and seed. Several researchers have conducted research of natural dyes source. Rubiadin dye was extracted from *Swietenia mahagoni* and its can be applied for dyeing of material textile without adding of mordant (Haque et al., 2013). Natural dyes from *Swietenia mahagoni* can be extracted using aquadest as solvent (Prayitno and Nurimaniwati, 2003).

Swietenia mahagoni is a tropical plant that grow well in Indonesia. *Swietenia mahagoni* can be found in Sumatera, Central Java, East Java, and South Sulawesi. The population of *Swietenia mahagoni* in Indonesia based on *Sensus Pertanian 2013* are about 71.50 millions. The bark of *Swietenia mahagoni* contain of flavonoids, tannins, and quinone that are all dyes compound. Therefore, *Swietenia mahagoni* can be original source for natural dyes.

Natural dyes extraction from *Swietenia mahagoni* can be done with conventional extraction methods like maceration, soxhlet extraction method, and reflux method. Conventional extraction method need high amount of solvent and long extraction time but extraction product not optimum. Nowadays, another extraction method was develop by ultrasonic wave. That method known as ultrasound-assisted extraction (UAE). Ultrasound is classified according to the frequency range from 20 kHz – 100 MHz. The broad region can be divided into two different region: power ultrasonic between 20 kHz and 100 kHz and diagnostic ultrasound between 1 and 100 MHz (Bendicho and Lavilla, 2000). The important part from extraction by ultrasonic wave is cavitation phenomenon. Cavitation occur because existence of pressure from ultrasonic wave that spread through the medium and induced oscillation of molecules (Mason and Dietmar, 2004).

Mechanism of ultrasound effect on heterogeneous medium has two type of cavitational collapse. First, cavitational collapse occurs on the surface of solid due to the presence of surface defects. Second, cavitational collapse occurs at near to a surface causing microstreaming of solvent to impinge on the surface. Irradiation of ultrasound induced particle rupture which result in a decrease in particle size (Bendicho and Lavilla, 2000).

Curcuminoid extraction by UAE method providing that extraction product three times higher than conventional method (Rouhani et al., 2009). Extraction time by UAE method eighteen times faster than steam distillation and 2.5 times faster than superheated water extraction (Roldán–Gutiérrez et al., 2008). UAE method can be effectively carried out at extraction temperature lower than conventional extraction. Capsaicinoids extraction by UAE method carried out at temperature 10–60^{o}C and the optimum temperature occur at 50^{o}C (Barbero et al., 2008). The result of that experiment show that UAE method can save energy and cost. In this

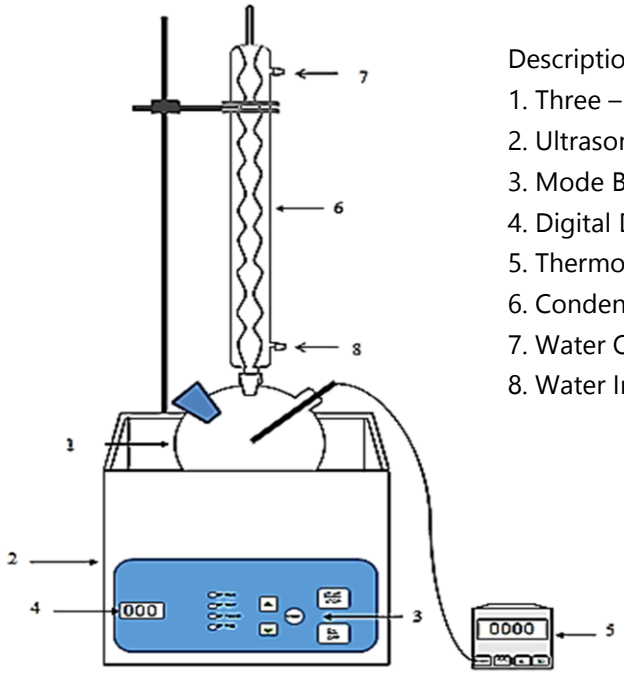

Fig. 1: Schematic representation of the ultrasound-assisted extraction apparatus used in this study

experiment will be studied about influence of extraction temperature to yield of *Swietenia mahagoni* extraction by UAE method.

MATERIALS AND METHODS

Material

Bark of *Swietenia mahagoni* was collected from Malang, East Java, Indonesia. The bark sample was dried under direct sunlight around 2–3 days. The dried bark of *Swietenia mahagoni* was grinded and strained to get uniform particle size. Aquadest was used as solvent to extract natural dyes compounds from the bark.

Experimental Setup

Ultrasonic-assisted extraction experiments were perfomed using ultrasonic cleaning bath (KRISBOW KW1801033, maximum frequency 40 kHz). Control experiments were performed with thermocouple that connect to thermo indicator. The experiment used three – neck flat flask as extraction vessel and condensor as cooling system as shown in Figure 1.

Ultrasound – assisted Extraction

The dried bark of *Swietenia mahagoni* (20 g) were extracted with 400 mL aquadest. The extraction was running for 40 minutes. Extraction temperature was maintained at around 30, 40, and 50°C. The extract was separated from bark samples and then was slowly heated using hot plate to evaporate the solvent. Mass of natural dyes powder from *Swietenia mahagoni* used for determine yield of extraction.

$$\text{yield of natural dyes} = \frac{\text{mass of natural dyes extract (gr)}}{\text{mass of dried bark (gr)}} x\ 100\% \quad (1)$$

In this process, the various solvents were used to investigate their effects on lipid yield.

RESULTS AND DISCUSSION

Natural dyes derived from flora are believed to be safe because eco–friendly, non–toxic, and non–carcinogenic. From this experiment, the effect of temperature had been studying and show that increasing temperature will be allow the increasing trend of yield. The result of extraction *Swietenia mahagoni* show in Table 1.

The result indicate that there is about 9.2748% improvement in the yield of extract due to increasing extraction temperature from 30°C to 50°C. The effect of increasing temperature related to increasing the number of cavitation bubbles and in the surface contact area. But, that effect will be decrease if the extraction temperature is near boiling point. Compared to the result of conventional extraction that done by Endro Kismolo Prayitno (2003), noted that UAE applicable at low temperature and faster than conventional extraction. The result of experiment done by Prayitno and Nurimaniwati (2003), show that extraction temperature at 60°C, extraction time 90 minute, and ratio 0.15 g/L gave 1.173%. While by UAE method with the extraction temperature at 30°C, extraction time 40 minute, and ratio 0.05 g/L gave result 1.2189%.

Beside of the effect of extraction temperature, the choice of solvent also influence the effectiveness of extraction process. Solvent that use for extraction natural dyes should have same polarity with dyes compounds. In this experiment, aquadest used as solvent because non–toxic and cheap. Therefore, the cost of extraction production can be reduce. Beside of cost reason, aquades has boiling point at 100°C as a consequence the range of extraction temperature wide.

Ultrasound irradiation will be induce the cavitation on the disruption of cell wall which increasing permeability of solid materials (bark of *Swietenia mahagoni*) so that solvent can penetrate into inner area. Cell wall disruption show at Figure 2. Increasing of temperature will be decrease the surface tensions of solvent so that cavitation convenient to formed.

Table 1: The natural dyes yield of *Swietenia mahagoni* extracted by ultrasound-assisted extraction

Mass of dried bark (g)	Extraction time (minutes)	Extraction temperature (°C)	Mass of natural dyes extract (g)	Yield (%)
20	40	30	0.2438	1.2189
20	40	40	0.2257	1.1285
20	40	50	0.2664	1.3319

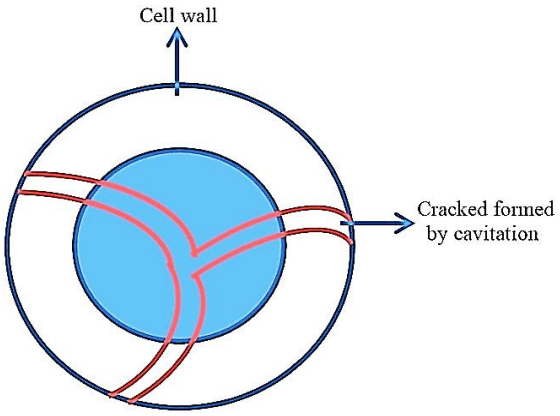

Fig. 2: Schematic representation of cell wall disruption due to cavitation phenomenon

CONCLUSION

This experiment show that Ultrasound-assisted Extraction (UAE) applicable to extract natural dyes from the bark of *Swietenia mahagoni*. This method applicable at low temperature and the extraction time faster than conventional extraction. The higher yield occurs at 50°C and the improvement is 9.2748% from 30°C to 50°C. Future studies will be aimed to study the influence of extraction time and combining solvent (aquadest – ethanol).

REFERENCES

1. Barbero, G.F., Liazid, A., Palma, M., Barroso, C.G., 2008. Ultrasound–assisted Extraction of Capsaicinoids from Peppers. Talanta, **75**, 1332–1337.
2. Bendicho, C., Lavilla, I., 2000. Ultrasound Extractions. In: Extraction. Academic Press, Cambridge, 1448–1454.
3. Crini, G., 2006. Non Conventional Low Cost Adsorbents for Dye Removal – A review. Bioresource Technology, **97**, 1061–1085.
4. Fu, Y., Viraraghavan, T., 2001. Fungal Decolourization of Dye Wastewaters – A review. Bioresource Technology, **79**, 251–262.
5. Haque, M.A., Khan, G.M.A., Razzaque, S.M.A., Khatun, K., Chakraborty, A.K., Alam, M.S., 2013. Extraction of Rubiadin Dye from *Swietenia mahagoni* and its Dyeing Characteristics onto Silk Fabric using Metallic Mordants. Indian Journal of Fibre and Textile Research, **38**, 280–284
6. Mason, T.J., Dietmar, P., 2004. Practical Sonochemistry: Power Ultrasound Uses and Application 2nd edition. Horwood Publishing, Cambridge, 5–6.
7. Prayitno, E.K., Nurimaniwati, 2003. Natural Dyes Extraction of Mahagony Waste (in Bahasa Indonesia). Proceeding of Meeting and Scientific Presentations of Basic Research in Science and Nuclear Technology, Yogyakarta, 208–213.
8. Roldán–Gutiérrez, J., Ruiz–Jiménez, J., Luque de Castro, M.D., 2008. Ultrasound–assisted Dynamic Extraction of Valuable Compounds from Aromatic Plants and Flowers as

Compared with Steam Distillation and Superheated Liquid Extraction. Talanta, **75**, 1369–1375.

9. Rouhani, S., Alizadeh, N., Salimi, S., Haji–Ghasemi, T., 2009. Ultrasound Assisted Extraction of Natural Pigments from Rhizomes of *Curcuma longa L*. Progress in Color, Colorants, and Coatings, **2**, 103–113.
10. Sivakumar, V., Vijaeeswarri, J., Anna J.L., 2011. Effective Natural Dye Extraction from Different Plant Materials using Ultrasound. Industrial Crops and Products, **33**, 116–122.