การขจัดทองแดงออกจากน้ำที่ปนเปื้อนด้วยการใช้ไบโอชาร์ที่เตรียมจากซังข้าวโพด

Copper Removing from Contaminated Water Using Biochar Derived from Corncobs

โยธิน กัลยาเลิศ[1] และชุมพร บุษบก[2]

Yotin Kallayalert and Chumphol Busabok

บทคัดย่อ

วัตถุประสงค์ของงานวิจัยนี้คือ เพื่อขจัดไอออนทองแดงออกจากน้ำด้วยถ่านไบโอชาร์ ถ่านไบโอชาร์ถูกเตรียมด้วยกระบวนการไพโรไลซีส โดยใช้ซังข้าวโพดที่เผาที่อุณหภูมิ 850 องศาเซลเซียสในบรรยากาศที่มีออกซิเจนต่ำ ถ่านไบโอชาร์ที่ได้ถูกนำมาตรวจคุณลักษณะด้วย SEM, EDS และ XRD ซึ่งพบว่า มีพลึกของแกร์ไฟต์และคาร์บอนเกิดขึ้นและมีรูพรุนอยู่ในช่วง 10-15 ไมโครเมตร หลังจากนั้น ไบโอชาร์ถูกบดด้วยเครื่องบดแฮมเมอร์มิลและคัดแยกด้วยตะแกรงร่อนเป็น 3 ช่วง (105-149, 149-177 และ 177-210 ไมโครเมตร) และนำไปจุ่มลงในสารละลายทองแดง 5-60 นาที เวลาในการดูดซับทองแดงจนอิ่มตัวของผงไบโอชาร์ทุกขนาดเท่ากับ 15 นาที อัตราการดูดซับสูงสุดคือ 0.8 มิลลิกรัมต่อกรัมนาที ด้วยขนาดอนุภาคที่อยู่ในช่วง 105-149 ไมโครเมตร

คำสำคัญ: ถ่านไบโอชาร์, ทองแดง, การดูดซึม

Abstract

The aim of this research is to remove copper ion from water by biochar. The biochar were prepared by pyrolysis process using corncob and fired at 850 °C in low oxygen atmosphere. The biochar were characterized by SEM, EDS and XRD. The results showed graphite and carbon crystalline and pore size about 10-15 μm. The biochars were crushed by hammer mill and separate size by sieve for 3 ranges (105-149, 149-177 and 177-210 μm) and dipped in the copper solution for 5-60 minute. The saturated copper absorption times of all size were about 15 minute. The maximum absorption rate is 0.8 mg/gmin by the size range 105-149 μm.

Keywords: Biochar, Copper, Absorption

[1] Assistant Professor, Faculty of Science and Technology, Valaya Alongkorn Rajabhat University under the Royal Patronage. 1 Moo 20 Phaholyothin Road, Klong Nueng, Klong Luong, PathumThani 13180 *E-mail: Yotin@vru.ac.th

[2] Expert Centre of Innovative Materials, Thailand Institute of Scientific and Technological Research (TISTR) 35 Moo 3 Klongha, Klong Luang, PathumThani 12120

Introduction

Industrial manufacturing including printed circuit board manufacturing, electronics plating, wire drawing, copper polishing, paint manufacturing, wood preservative using and printing operations are copper ion source of wastewater (Salmani et al., 2012). Copper is a heavy metal that is naturally observed in the environment and in fragmented water resources. The discharge of wastewater including heavy metals increases the environmental pollution and toxic nature of Cu^{2+} affects water resources (Jarup, 2003). Copper ion is an essential element for health of plants, animals and humans (Kumar, 2006). Copper is not biodegradable in environment, so it accumulates such as other heavy metals and may cause adverse effects. High concentration of copper compounds in drinking and agriculture water sources is the biggest threat to human health so that, in human it creates a kind of disease which is similar to flu (Olivares et al., 1998 and Dragan et al., 2009).

To protect humans and environment, removal of copper ion from water is important. There are several methods to remove copper ion from water such as coagulants, oxidizing agents, membranes, ion flotation (Salmani et al., 2012), the use of nanoparticles, adsorption processes and electrochemical techniques. The adsorption process is cheaper and simpler than other method. So that biochar is interest to use to absorb copper ion in wastewater. This is because biochar can be easy prepared in rural of Thailand.

Biochar is porous carbon-rich materials produced by pyrolysis of biomass in range of temperatures 150-900°C under low oxygen atmosphere (Beesley et al., 2011). The properties of biochar were depend on pyrolysis temperature. The porosity of biochar increased with pyrolysis temperature (Ahmad et al., 2014). The porosity is important to absorption properties of biochar. Particle size of biochar is also interest to study the absorption of heavy metal. So that the aims of this research was to study the particle size of corn cob biochars to remove copper ion from water.

Materials and methods

Pyrolysis process was used to prepared biochars from corncobs. Before the pyrolysis tests corncobs were dried by sunshine for 5 days and measured moisture content. corncobs

were undertaken in a vertical firewood kiln under low oxygen atmosphere. The vertical firewood kiln was fired at temperature 850°C at outside but inside kiln temperature about 450°C and hold temperature until the pyrolysis vapors which released from dried corncobs and burnt by fire outside of kiln were completed. The corncobs were changed to biochar. The corncob bio-charcoals were characterized by SEM to observed microstructure, EDS to analyzed chemical composition and XRD to analyzed phase composition.

The biochar was reduced size by hammer mill and separated by sieves for 3 ranges of 105-149, 149-177 and 177-210 μm. The different size of biochars for 1 gram were dipped in 100 ml. of water which has copper 1 mg/l for 5,10, 15, 20, 30, 45 and 60 minute. Atomic absorption spectrometer (AAS) was used to analyzed copper ion content in water after dipping.

Results and discussion

1. Corncob biochar analysis

After pyrolysis test, SEM, EDS and XRD were used to characterize biochar which the results were shown as follows.

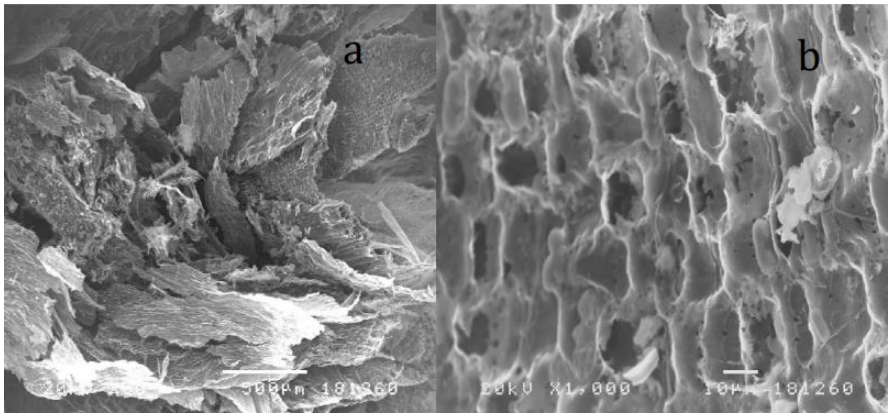

Fig. 1 Microstructures of corncob biochar (a) x 50 (b) x 1000

Microstructures of the biochar from corncob were shown in Fig. 2. The celluloses are arranged in a charcoal as a sheet and porous consistency. Pore size is in the range of 10-15 μm.

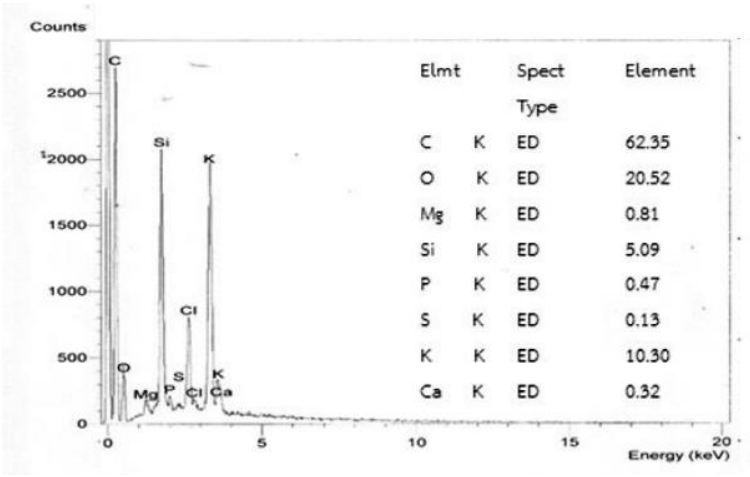

Fig. 2 EDS spectra and chemical composition of corncob biochar

Chemical composition of corncob biochar which shown in Fig. 2 were composed of carbon 62.35 %, oxygen 20.52%, potassium 10.30 %, silicon 5.05 % and few of magnesium, phosphorous, calcium and sulfur respectively. corncob biochar have significant potassium and silicon content.

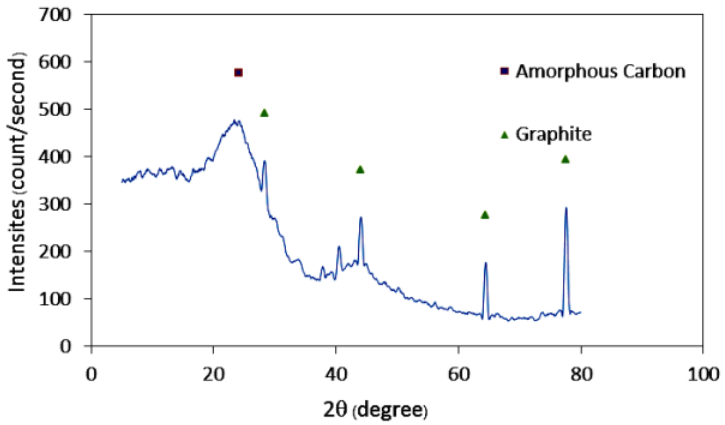

Fig. 3 XRD pattern of corncob biochar

Fig. 3 Corncob biochar were analyzed by XRD. The XRD pattern was shown amorphous carbon and graphite which formed at high temperature.

2. Copper removing by biochar

The corncob biochars were crushed by hammer mill and separated by sieve for the range of 105-149, 149-177 and 177-210 μm to dip in copper solution of 1 mg/l concentration. Specific surface areas of biochar were shown in table 1. The solutions after dipping were characterized by AAS. The results were shown in Fig. 4.

Table 1. Specific surface are of corncob biochar.

Size range (μm)	Specific surface area (m^2/g)
177-210	124
149-177	179
105-149	220

Specific surface area is inverse variation with particle size. The size increase but specific surface area decrease.

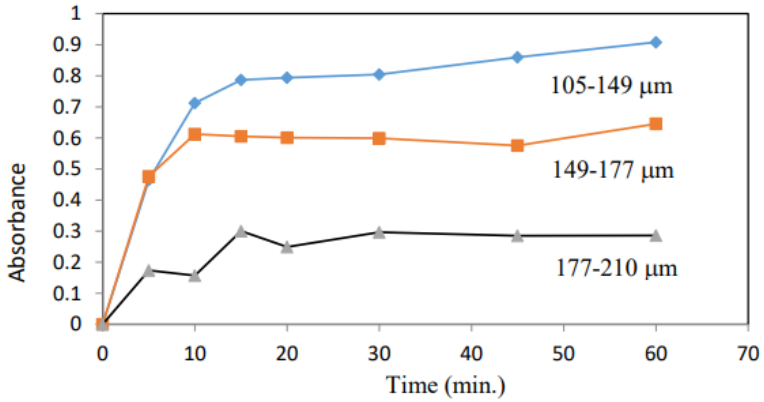

Fig. 4 Copper ion absorption of the corncob biochars

Fig. 4 the corncob biochars were dipped in copper solution to absorbed copper ion. Every size range can be absorbed copper ion until saturated for 15 minute. The absorption depended on particle size. The size range of 177-210, 149-177 and 105-149 μm were saturated approximate 0.3, 0.6 and 0.8 milligram of copper per gram of biochar respectively. The absorption rates are about 0.02, 0.06 and 0.08 mg/gmin respectively.

Conclusion

The corncob biochars synthesis by pyrolysis process and used to removed copper ion from water can be concluded as follow.

1. The biochar consist of Carbon and oxygen as main element and have significant Potassium and Silicon content.

2. Pore size of biochar was about 10-15 μm and found carbon and graphite crystalline in biochar synthesis.

3. The biochar can be absorbed copper ion and saturated at 15 minute. The maximum absorption rate is 0.8 mg/gmin.

References

Ahmad, M., Rajapaksha, A.U., Lim, J.E., Zhang, M., Bolan, N., Mohan, D.,Vithanage, M., Lee, S.S., Ok, Y.S., (2014). **Biochar as a sorbent for contaminant management in soil and water: a review.** Chemosphere 99, 19-33.

Beesley, L., Moreno-Jimenez, E., Gomez-Eyles, J.L., Harris, E., Robinson, B., Sizmur, T., (2011). **A review of biochars' potential role in the remediation, revegetation and restoration of contaminated soils.** Environ. Pollut. 159 (12), 3269-3282.

Dragan ES, Dinu MV. (2009). **Removal of copper ions from aqueous solution by adsorption on ionic hybrids based on chitosan and clinoptilolite.** Ion Exchange Letters.2,15-8.

Gao, L.Y., Deng, J.H., Huang, G.F., Li, K., Cai, K.Z., Liu, Y., Huang, F., (2019). **Relative distribution of Cd2+ adsorption mechanisms on biochars derived from rice straw and sewage sludge.** Bioresour. Technol. 272, 114-122.

Jarup L. (2003). **Hazards of heavy metal contamination.** Br Med Bull.68: 167-82.

Kumar M, Singh S, Mahajan RK. (2006). **Trace level determination of u, zn, cd, pb and cu in drinking water samples.** EnvironMonit Assess.112 (1-3), 283-92.

Olivares M, Pizarro F, Speisky H, et al. (1998). **Copper in infant nutrition :safety of world health organization provisional guideline value for copper content of drinking water.** J Pediatr Gastroenterol Nutr. 26(3),251-7.

Salmani M.H et al. (2012). **Removing Copper from Contaminated Water Using Activated Carbon Sorbent by Continuous Flow.** Journal of Health Researches. 1(1), 11-18.