Utilization of Silica (SiO_2) as Heavy Metal Adsorben Batik Liquid Waste

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Abstract

Batik industry is a potential industry from the initial process until the process of refinement indicated the use of chemicals containing heavy metal elements. The batik waste still contains heavy metals such as Fe. High Fe content in wastewater can contaminate the aquatic environment when disposed of into rivers or irrigation canals. The adsorption process is an effective purification and separation technique used in industry to reduce heavy metal ions in wastewater. Silica has Si-O-Si and Si-OH active groups which can be used as Fe metal adsorbents. Silica is inert, has good adsorption and ion exchange properties, is easily modified with certain chemical compounds, high mechanical and thermal stability, and can be used for preconcentration or analytical separation because the analytical binding process on the silica surface is reversible. Research has been conducted to find out optimal stirring time on silica adsorbent in adsorpting Fe metal contained in batik waste of Sudagaran village, Banyumas. There are four samples tested by AAS method each of 400 mL volume and reddish-brown. Sample 1 has not been carried out by adsorption of silica or as a control. Samples 2, 3, and 4 were adsorbed silica of the same mass but treated with time variations. Samples 2, 3, and 4 were stirred with variations in consecutive times of 20, 40, and 60 minutes. The results showed that 40 minute stirring time was the optimal time for silica in adsorbing Fe metals. There was a decrease in Fe content from 0.287 mg/L to 0.145 mg/L.

Keywords: adsorption, batik waste, Fe metal, silica

Introduction

Batik is one of Indonesia's cultural richness which has received international recognition from UNESCO on 2 October 2009. This UNESCO recognition becomes a pride and challenge for Indonesian nation (Directorate General Small and Medium Industry, 2011). Ministry of Industry states that the domestic batik industry has now risen marked by the increasing production of batik every year. In 2010 the value of batik industrial production reached 732.67 billion, up 13% from the previous period. Data from the Ministry of Industry showed that the number of batik business units for five years from 2011-2015 grew by 14.7% from 41,623 units to 47,755 units. In addition, the high value of batik is seen from the export of batik which rose by 10% from the previous year, in 2015 reached USD 156 million or equivalent to 2.1 trillion (Ministry of Industry, 2016).

The increasing demand and purchase of batik impact on the growth and development of batik industrial centers in various regions in Indonesia. Purwaningsih (2009), batik process in outline consists of pengolaan, batik tulis, dyeing / dyeing, pelodoran / removal of candles, and refinement. Batik industry activity in addition to give a positive impact, there are also negative impacts for the environment. The number of batik producers, both large and household scale will produce batik liquid waste with dyestuffs, suspended solids, BOD (Biolologycal Oxigen Demand), COD (Chemical Oxigen Demand), oils and fats that need treatment before discharged into water bodies (Setyaningsih *et al.*, 2006). Dye dyeing wastes in the batik industry or other textile factories, which are large enough to cause environmental pollution because the environment has limited ability to degrade the dye. The content of batik waste contained in table 1.

Table 1. The content of batik waste

Parameters	Standard (mg/L)
Fe	-
Cu	-
Zn	-
Cd	-
Pb	-
Cr	1
pH	6-9
COD	150
Ammonia	8
Phenol	0,5
TSS	50
Sulfide	0,3

Agustina *et al.*, 2011

The presence of heavy metals in water or wastewater with concentrations exceeding the threshold may adversely affect the normal biological cycle in the environment. Among the harmful environmental pollutant metal ions are Cadmium, Lead, Zinc, Mercury, Copper, and Iron (Connel and Miller, 1995). A variety of metal heavy metal extracting techniques have been developed, such as filtration, chemical precipitation, ion exchange adsorption, electro-deposition, and membrane systems (Pradhan *et al*, 2005). One of the most widely developed techniques is the principle of solid phase extraction by using certain adsorbents because they do not require harmful solvents. Recent metal ion waste control efforts are increasingly leading to the search for new, inexpensive, effective and efficient methods. One of them by using activated charcoal as a medium to absorb the metal.

Rice husk as agricultural waste is still possible to be utilized as an adsorbent in the presence of organic ingredients. The main compounds of rice husk cell wall are polysaccharides ie crude fiber or cellulose, lignin, and hemicellulose having hydroxyl groups which can play a role in the adsorption process (Balittan, 2009). The adsorption process occurs because of the interaction of metals with functional groups present on the surface of the adsorbent, generally containing functional groups -OH, -NH, -SH, and -COOH (Stum and Morgan, 1996). In addition, rice husk ash is a very potential material As a heavy metal absorbent material in water. Rice husk ash may be used as an adsorbent because besides being a porous material also has an active group of Si-O-Si and Si-OH (Setyaningtyas *et al*, 2005).

In this research will be done batik waste treatment with Fe metal absorption using silica. The source of silica is obtained from the rice husk that is made into nanoparticles through certain stages. The purpose of this study was to determine the optimum time of silicon in adsorbing Fe metal in batik waste.

Material and Method

The materials used in this research are silica and batik liquid waste. The tools used in this study include stirrer, 500 mL beaker glass, and spatula. For analysis of adsorption result used Atomic Absorption Spectrophotometry (AAS). The research procedure is as much as 400 mL of batik liquid waste inserted into beaker glass. Adsorption is done in a batch system by adding a silica spatula into batik wastewater. The mixture of silica and batik liquid waste is stirred using a mixer with variations of time 20, 40, and 60 minutes. Each sample was analyzed with an Atomic Absorption Spectrometer (AAS) to determine the adsorbed Fe metal content.

Result and Discussion

The adsorption method has been widely used in batik wastewater purification. The adsorption method can reduce the heavy metal content in batik liquid waste by absorbing the metals onto the surface of the adsorbent. The adsorption process is affected by the functional group, the functional group position, the double bond, the chain structure of the absorption compound. In addition, the adsorbed metal diameter also affects the adsorption process. According to Uzun and Guzel (2000), Fe metal ions have a diameter of 76 μm. Other factors that may also affect the adsorption rate include the characteristics of the adsorbent, the pH of the solution, the temperature, the size of the adsorbent and the stirring time (Putra *et al*., 2014).

Silica is a porous solid, this porous structure corresponds to the surface area, the smaller the pore size of the silica results in the larger surface area so that the adsorption capacity increases. In addition, silica has unique properties not possessed by other inorganic compounds, such as inert properties, good adsorption and ion exchange properties, easily modified with certain chemical compounds to improve its performance, mechanical stability and high thermal stability, and may be used for preconcentration or Analytical separation because the analytical binding process on the silica surface is reversible (Pyrzynska and Wierzbicki, 2005). The silica used in this research is the characterization silica. The characterized silica surface causes the presence of silanol (-SiOH) and siloxane (Si-O-Si) groups which allow it to bind the metal ion more selectively by a particular mechanism (Mahmoud *et al*, 2000).

The timing is used to obtain optimal stirring time during the batch process so that the adsorbent can adsorb the adsorbate to the maximum adsorption limit. Optimization of the adsorption capacity of silica to Fe heavy metal in liquid batik waste is done by variation of stirring time. Previously, characteristic of liquid batik waste and Fe content of 0.287 mg/L. The adsorption capacity with variation of stirring time on Fe metals resulted in iron content of Fe in a circulation time of 20 minutes, 40 minutes, and 60 minutes, respectively of 0.182 mg/L, 0.145 mg/L, and 0.185 mg/L. Adsorption of Fe metals is best in a 40 minute time circulation with a percentage of 49.47%. The rate of silica adsorption with time variation in this study is shown in Figure 1.

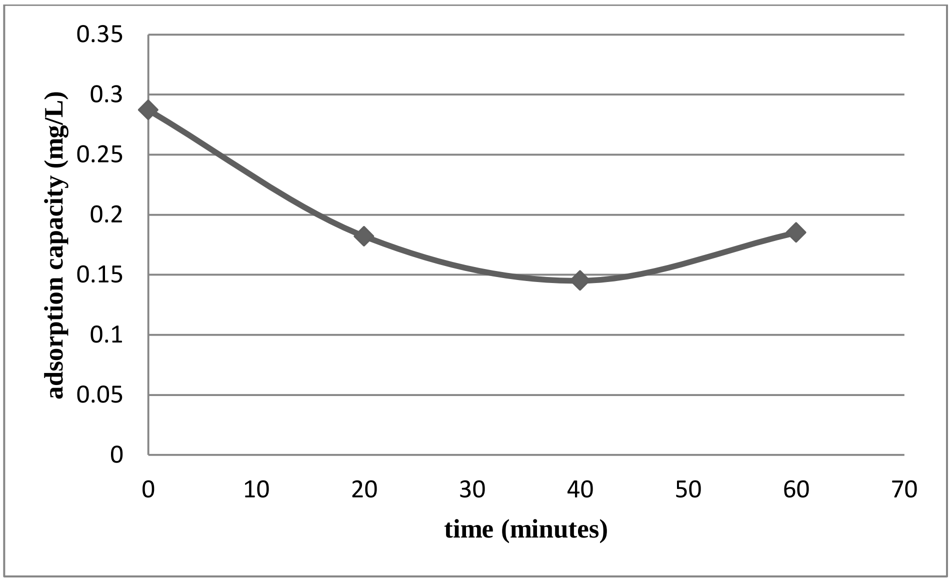

Fig. 1 Time optimum adsorption by Silica

The longer the interaction time, the more the amount of Fe metal ions. Active silica becomes adsorbent for up to 40 minutes, and further decreases the effectiveness of silica adsorption. This is because after more than 40 minutes, the silica adsorbent begins to reach saturation point so that in this condition the metal ions bound to the silica surface will be released again.

Conclusion

Silica can be used as heavy metal adsroben Fe in batik wastewater with adsorption optimal time of 40 minutes where there is decrease of Fe content from 0,287 mg/L to 0,145 mg/L with percentage 49,47%.

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