International Journal Of
Technology Science

Vol. 1, No. 1 March 2023, Hal. 9-16
DOI: https://doi.org/XX..XXXXX/ijts

ADDING ACRYLIC ACID TO HEMP ADSORBENT ON METAL ION ADSORPTION CAPABILITY

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Abstract

The presence of hazardous heavy metals in waste can have a negative impact on the environment and human health due to industrial waste that pollutes the environment. Waste in the industrial environment must be free from unwanted impurities, including heavy metals. One of the efforts to reduce heavy metal contaminants is the adsorption process. The adsorption process can occur chemically or physically, the success of the adsorption process is greatly influenced by the adsorbent used. The use of hemp as a metal adsorption has various disadvantages so that modifications are needed with the copolymerization grafting method using a monomer of the acrylic-styrene acid mixture so that it is able to better adsorb metals. This study aims to characterize the adsorbent ability of Rami- AA 50% and Rami-AA-STI in adsorption of some metals. In this study, by grafting hemp with a mixture of acrylic-styrene acid monomers (99%:1%), then irradiated with dose variants of 5, 10,15,20, 30 and 40 KGy. The results obtained The best results for the degree of polymerization occurred when hemp AA was 50% at a dose of 40 kGy, namely 257% and at hemp AA-Sti 1% at a dose of 20 kGy, which was 258%, the degree of grafting fluctuated up to several%. The adsorption capacity of hemp against Pb metal ion solution is best at a dose of 30 KGy with an absorption capacity of hemp AA-Sti 1% of 2.94, Cr metal ion, namely Rami AA 50% 10 kGy of 5.59, Cu metal ion, namely Rami AA sample 4ml + 1% styrene 40 kGy of 3.38 and 4ml AA Rami sample + 1% styrene 10 kGy of 1.88.

Keywords : *Adsorbent, Acrylic Acid, Metal Ions, Hemp.*

INTRODUCTION

Plants have many benefits that can be utilized. One of them is hemp which is an annual clumping plant that produces fiber from wood. This plant is also used as raw material for textile products because it has similarities to cotton. The hemp plant originates from central and western China, until now this plant is growing well in that country. The hemp plant produces fiber from its bark which is used as raw material for textiles. Apart from being known as a fertilizer and animal feed, it also has several medicinal properties. (Dahlan, 2011)

In certain cases, hemp fiber has advantages over other fibers, such as tensile strength, water absorption, resistance to moisture and bacteria and resistance to heat. The hemp plant is a type of bast fiber plant that grows abundantly in Indonesia, such as in the Garut area West Java and Wonosobo, Central Java. Until now, most hemp fiber products were exported to Japan. Increasing the strength of natural fiber composites can be done in 2 ways, namely by chemically treating the fibers or by adding a coupling agent. The chemical treatment of fibers that is often carried out is alkaline treatment such as NaOH, because it is more economical and more effective in reducing the lignin layer which increases the binding strength on the surface of the hemp fiber. By using hemp fiber in natural fiber-based composites. Composite is a material resulting from the combination of two or more basic materials arranged macroscopically (Gibson, 1994). Industrial waste is defined as the waste product from industrial processes or other public places, and generally contains materials or substances that can endanger human health and disrupt the environment. Chemically, waste consists of organic and inorganic chemicals with certain concentrations (Sari, 2018). One of the pollutants found in industrial liquid waste is heavy metals. Heavy metals in industrial waste are usually in the form of arsenic (As), cadmium (Cd), chrome (Cr), lead (Pb), copper (Cu), and zinc (Zn), where heavy metals in industry are usually used as catalysts in processing processes. making products until they become the main ingredient in the industrial process (Komarawidjaja, 2017).

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Research conducted by Meri and Nunung (2017) determined the characteristics of cell-g-AA-St copolymers compared to cell-g-AA, including the degree of swelling, physical strength against acids and the ability to adsorb metal ions Pb2+, Mn2+ and Ni2+. In this research, cellulose modification to improve its physical and chemical properties was carried out using engineering grafting by simultaneous irradiation using a cellulose matrix isolated from rice straw and a mixture of acrylic acid monomer (hydrophilic monomer) and styrene (hydrophobic monomer), with a gamma ray initiator from a cobalt-60 source. It is hoped that the addition of styrene monomer can improve the physical and chemical properties of the cell-g-AA copolymer, especially reducing the degree of swelling and increasing the adsorption ability of metal ions. The results showed that the optimum irradiation dose for the grafting process of acrylic acid and styrene on cellulose was achieved at 30 kGy. In simultaneous grafting with an irradiation dose of 30 kGy, with the addition of styrene, there was an improvement in the degree of expansion (%S), the %S of Sel-g-AA copolymer which was originally 470% decreased to 89%. The results showed that the optimum irradiation dose for the grafting process of acrylic acid and styrene on cellulose was achieved at 30 kGy. In simultaneous grafting with an irradiation dose of 30kGy, with the addition of styrene, there was an improvement in the degree of expansion (%S), The %S of Sel-g-AA copolymer which was originally 470% decreased to 89%.

Research by Naufal et al., (2021) shows that hemp fiber and hemp fiber waste are environmental alternative materials that can be applied as sound absorbers in home building applications to reduce the level of disturbance. The highest density value achieved by hemp fiber composite at a ratio of 95:5 was 1.7 gr/cm3. The research aims to manufacture composites based on hemp fiber reinforcement and hemp fiber waste for sound dampening material applications.

Research (Muslimin, 2022) namely the use of hemp fiber as a composite material with a polymer matrix. The problem raised in this research is to find out how big the tensile strength of the fiber is. The process is carried out using Soak the fiber in several chemical solutions such as 5% NaOH, 99% ethanol. After this process the fiber is then tested for tensile strength. Increasing the compatibility of hemp fiber which has hydrophilic properties with a hydrophobic polymer matrix, namely reducing the air fiber content, especially that which is absorbed by the fiber surface by sizing. Research (Gatot, 2020) is the addition of acrylic acid monomers to modified chitosan to add added value to natural and synthetic polymers. To get a new type of polymer with certain functional groups, you can add monomers to the polymer framework. So far no one has used hemp fiber as an adsorbent, this has led to this research using hemp fiber as a metal adsorbent in waters because it has quite high cellulose at 68% - 76% by using a mixture of acrylic acid-styrene which varies as an adsorbent. able to have the ability to adsorb metal better.

METHOD

The research I carried out began in October 2021 to April 2022 at the Research Center for Nuclear Radiation Detection and Analysis Technology (PRTDRAN) of the National Research and Innovation Agency (BRIN) Lebak Bulus, South Jakarta City. The tool used in this research was PAIR-BATAN's Multipurpose Panoramic Irradiator with a gamma ray source (Co-60). The equipment used in isolation is a 1000 ml measuring cup, distilled water, spatula, water bath. Then for the next process use a petri dish, measuring flask, plastic, seal tool, oven, measuring pipette, analytical balance (AND GR-200), funnel, filter paper. The instrument used to read the metal content is an atomic absorption spectrophotometer (Shimadzu AA- 6800). The materials I use when isolating are hemp, NaOH 2.5%, distilled water. Then for the next process use 50% acrylic acid, 1% styrene, $CuSO_4$, $K_2Cr_2O_7$, $Pb(CH_3COO)_2.3H_2O$, $NiSO_4.6H_2O$. The hemp is shredded until smooth and washed with distilled water until clean, then given 2.5% NaOH until all the hemp is soaked for 5 hours at a temperature of 100^oC.

RESULTS AND DISCUSSION

Hemp Activation

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Activation is a process to remove impurities so that it will activate the existing active groups. The function of activation in this research is to dissolve compounds in hemp fiber that can inhibit the hemp cellulose adsorption process. Structurally, hemp fiber is composed of cellulose, hemicellulose, lignin, pectin, wax and water content (Purwati, 2012).

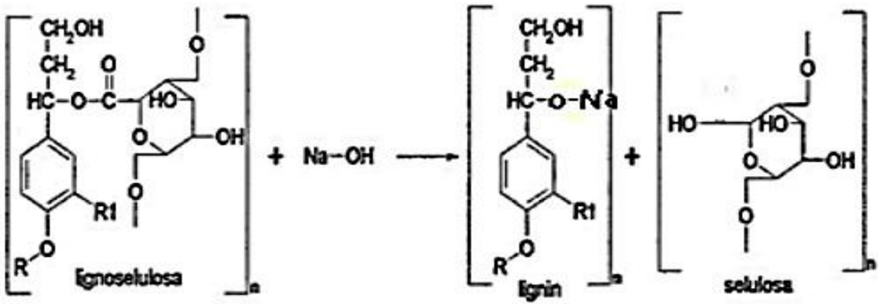

Figure 1. Mechanism of breaking the bond between lignin and cellulose using NaOH (Source: Fengel & Wegeneer, 1995)

After the activation process, the visual shape and color of the hemp fiber were observed. Visually, the shape of hemp fiber is elongated fiber. The physical characteristics of natural hemp fiber are green, while active hemp fiber is white, this indicates the pigment has been dissolved. In hemp fiber there are cellulose, lignin, hemicellulose and other compounds that dissolve in air. The presence of lignin will reduce the adsorption process. This is because the presence of high lignin indicates a high density which will hinder the ion transfer process, in this case cadmium, to the active side of the adsorbent. Lignin dissolves in NaOH solution. Hemicellulose is a polysaccharide of mannose and galactose. The presence of hemicellulose will increase the sorption process, the more hemicellulose the greater the adsorption capacity (Han, 1999). Lignin and hemicellulose both dissolve in NaOH.

Graft Copolymerization of Hemp-AA 50% and Hemp-AA-Sti 1%

The isolated cellulose was grafted with 50% acrylic acid as sample A and 1% styrene acrylic acid as sample B, for the initiator using gamma ray radiation from a Co-60 Irradiator (natural rubber irradiator, IRKA) with dose variations, namely 5, 10, 20, 30 and 40 kGy. The reason for choosing gamma rays as the initiator is because this initiator is environmentally friendly, because it does not cause chemical residues. The process carried out using radiation is also more optimal, because all samples are exposed to rays that can penetrate the sample. Meanwhile, the grafting technique uses a simultaneous irradiation technique. In the grafting process there are three stages, the first is initiation, where the monomer and polymer are irradiated so that they form radicals.

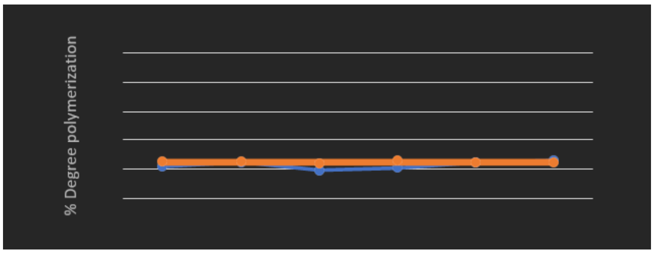

Figure 2. Comparison graph of degree of grafting with radiation dose.

Based on Figure 2, the resulting hemp cellulose has an increase in the degree of polymerization that is directly proportional to the increase in radiation dose. The increase in polymerization content can be caused by the increasing number of radicals in cellulose that are formed, which means the greater the possibility of the initiation process occurring. The best grafting degree results occurred when 50% AA hemp at a dose of 40 kGy was 25% and for 1% AA-

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Sti hemp at a dose of 20 kGy was 25%, the degree of polymerization experienced ups and downs of up to several %.

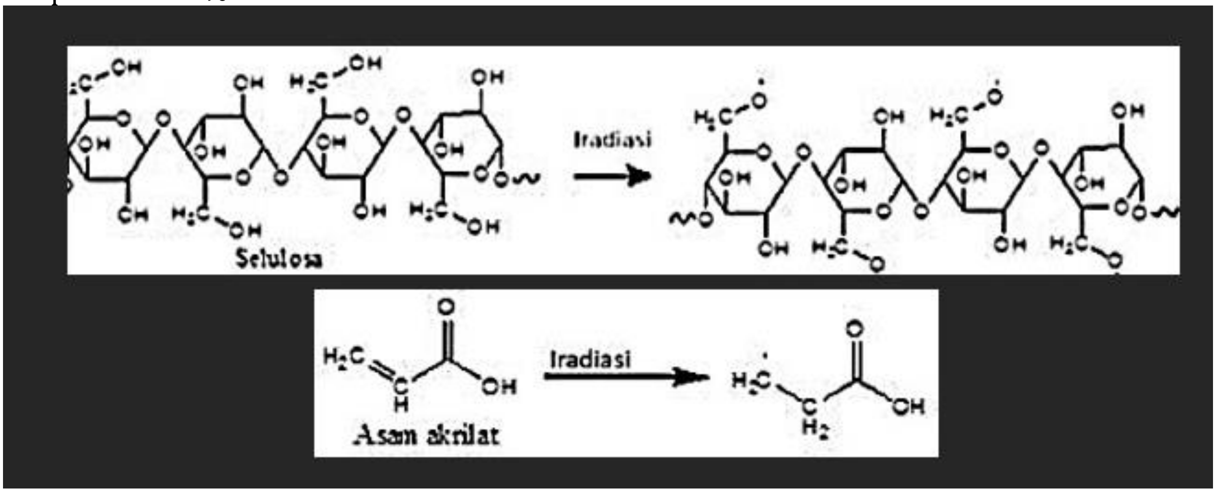

Figure 3. Initiation stage reaction mechanism (Source: Meri, 2015)

The reaction using irradiation can be seen in Figure 3. The success of graft copolymerization is determined by the number of acrylic acid and methyl methacrylate monomers grafted onto cellulose as the irradiation dose increases. Success is expressed as grafting degree (% grafting). A graph of the relationship between the degree of grafting and the irradiation dose on the cellulose-AA-MMA copolymer at two different monomer concentrations.

Adsorption of Cu, Cr, Ni and Pb metal ions and their measurement using an Atomic Adsorption Spectrophotometer (AAS)

Table 1. Addition of Cu Metal Acrylic Acid

No.	Name	Abs	Qe (mg/g)	ε (%)
1	Cu standard 20 ppm	0,03557		
2	Hemp without radiation	0,03419	0,17	4,06
3	Hemp AA 50% 5 KGy	0,03109	0,56	13,19
4	Hemp AA 50% 10 KGy	0,03497	0,07	1,77
5	Hemp AA 50% 15 KGy	0,02963	0,74	17,49
6	Hemp AA 50% 20 KGy	0,02941	0,78	18,13
7	Hemp AA 50% 30 KGy	0,03073	0,61	14,25
8	Hemp AA 50% 40 KGy	0,03115	0,51	13,01
9	AA Hemp Sample 4ml + stir 1% 5 KGy	0,01783	1,91	52,22
10	AA Hemp Sample 4ml + stir 1% 10 KGy	0,01382	2,73	64,03
11	AA Hemp Sample 4ml + stir 1% 15 KGy	0,01340	2,48	65,26
12	AA Hemp Sample 4ml + stir 1% 20 KGy	0,01417	2,71	63,00
13	AA Hemp Sample 4ml + stir 1% 30 KGy	0,01419	2,58	62,94
14	AA Hemp Sample 4ml + stir 1% 40 KGy	0,00671	3,38	84,96

Based on the results of the research that has been carried out, it can be concluded that the adsorption of Cu metal ions is 15 KGy for the 4ml AA Hemp + 1% styrene sample, the 4ml AA Hemp + 1% styrene sample is 20 KGy, and the 4ml AA Hemp + 1% styrene sample is 40 KGy.

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Table 2. Addition of Cr Metal Acrylic Acid

No	Name	Abs	Qe (ml/gr)	ε (%)
1	Cu standard 20 ppm	0,041		
2	Hemp without radiation	0,008	5,28	88,31
3	Hemp AA 50% 5 KGy	0,008	5,21	87,10
4	Hemp AA 50% 10 KGy	0,006	5,59	93,42
5	Hemp AA 50% 15 KGy	0,009	5,11	85,44
6	Hemp AA 50% 20 KGy	0,010	4,90	81,92
7	Hemp AA 50% 30 KGy	0,010	4,91	82,18
8	Hemp AA 50% 40 KGy	0,010	4,88	81,65
9	AA Hemp Sample 4ml + stir 1% 5 KGy	0,015	4,07	67,99
10	AA Hemp Sample 4ml + stir 1% 10 KGy	0,014	4,27	71,36
11	AA Hemp Sample 4ml + stir 1% 15 KGy	0,019	3,51	58,67
12	AA Hemp Sample 4ml + stir 1% 20 KGy	0,023	2,80	46,78
13	AA Hemp Sample 4ml + stir 1% 30 KGy	0,017	3,82	63,91
14	AA Hemp Sample 4ml + stir 1% 40 KGy	0,033	1,37	22,87

Based on the results of the research that has been carried out, it can be concluded that the adsorption of Cr metal ions is on hemp samples without radiation, 50% AA Hemp Samples 5 KGy, 50% AA Hemp Samples 10 KGy and 50% AA Hemp Samples 15 KGy. The adsorption effect is most obvious and the adsorption effect does not increase with increasing neutralization degree when the neutralization degree of acrylic acid is 65%.

Table 3. Addition of Pb Metal Acrylic Acid

No	Name	Abs	Qe (mg/g)	ε (%)
1	Cu standard 20 ppm	0,023		
2	Hemp without radiation	0,012	2,265	53,96
3	Hemp AA 50% 5 KGy	0,017	1,163	31,05
4	Hemp AA 50% 10 KGy	0,015	1,457	37,30
5	Hemp AA 50% 15 KGy	0,012	2,123	50,62
6	Hemp AA 50% 20 KGy	0,019	0,727	17,63
7	Hemp AA 50% 30 KGy	0,008	2,660	70,99
8	Hemp AA 50% 40 KGy	0,017	1,141	28,60
9	AA Hemp Sample 4ml + stir 1% 5 KGy	0,020	0,487	12,59
10	AA Hemp Sample 4ml + stir 1% 10 KGy	0,011	2,349	58,07
11	AA Hemp Sample 4ml + stir 1% 15 KGy	0,020	0,607	15,18
12	AA Hemp Sample 4ml + stir 1% 20 KGy	0,020	0,593	16,29
13	AA Hemp Sample 4ml + stir 1% 30 KGy	0,008	2,946	71,40
14	AA Hemp Sample 4ml + stir 1% 40 KGy	0,007	2,913	75,57

Based on the results of the research that has been carried out, it can be concluded that the adsorption of Pb metal ions is 30 KGy for 50% AA Hemp samples, 4ml AA Hemp + 1% styrene samples 30 KGy, and 4ml AA Hemp + 1% styrene samples 40 KGy.

Table 4. Addition of Ni Metal Acrylic Acid

No	Name	Abs	Qe (mg/g)	ε (%)
1	Cu standard 20 ppm	0,01631		
2	Hemp without radiation	0,01515	0,24	7,89

3	Hemp AA 50% 5 KGy	0,01228	0,76	27,40
4	Hemp AA 50% 10 KGy	0,01224	0,80	27,67
5	Hemp AA 50% 15 KGy	0,01215	0,88	28,28
6	Hemp AA 50% 20 KGy	0,01205	0,88	28,96
7	Hemp AA 50% 30 KGy	0,00983	1,22	44,05
8	Hemp AA 50% 40 KGy	0,01088	1,09	36,91
9	AA Hemp Sample 4ml + stir 1% 5 KGy	0,01589	0,08	2,86
10	AA Hemp Sample 4ml + stir 1% 10 KGy	0,00704	1,88	63,02
11	AA Hemp Sample 4ml + stir 1% 15 KGy	0,00771	1,73	58,46
12	AA Hemp Sample 4ml + stir 1% 20 KGy	0,00931	1,28	47,59
13	AA Hemp Sample 4ml + stir 1% 30 KGy	0,00815	1,69	55,47
14	AA Hemp Sample 4ml + stir 1% 40 KGy	0,01096	1,04	36,37

Based on the results of the research that has been carried out, it can be concluded that the adsorption of Ni metal ions is 10 KGy for the 4ml AA Hemp + 1% styrene sample, the 4ml AA Hemp + 1% styrene sample is 15 KGy, and the 4ml AA Hemp + 1% styrene sample is 30 KGy. Based on the results obtained, a high concentration will cause the number of molecules in the solution to increase, thereby increasing the interaction of the adsorbate molecules with the adsorbent and causing the adsorption capacity value to increase. The effect of concentration on adsorption capacity and adsorption efficiency, the higher the initial concentration of a metal, the value of adsorption capacity and adsorption efficiency also increases.

CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that: The best polymerization degree results occurred when 50% AA hemp at a dose of 40 kGy, namely 257% and for 1% AA-Sti hemp at a dose of 20 kGy, namely reaching 258%, the degree of grafting experienced ups and downs up to several %. The adsorption capacity of flax on the Pb metal ion solution was the best at a dose of 30 KGy with the absorption capacity of 1% AA-Sti flax being 2.94, Cr metal ions, namely AA 50% Rami 10 kGy, 5.59, Cu metal ions, namely AA Rami Samples. 4ml + 1% styrene 40 kGy is 3.38 and the Hemp AA sample 4ml + 1% styrene 10 kGy is 1.88.

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