Effectiveness Test of Silica Gel from Rice Husk and Coffee Grounds as Adsorbent

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Research Question drafts

How to utilize rice husk and coffee grounds for production of silica gel that is effective as an adsorbent and what are the characteristics that affect the effectiveness of silica gel produced from rice husk and coffee grounds?

Introduction

Indonesia is one of the main producers in the rice farming and coffee plantation subsectors. The process produces rice husk and coffee grounds waste and is still a problem that is difficult to overcome until now. Rice husk itself contains 86.90-97.30% silica (SiO2), making it a potential source for the preparation of absorbent materials such as silica gel. On the other hand, coffee grounds are also rich in activated carbon and have the ability to absorb chemicals.

Commercial silica gel production generally requires expensive synthesized raw materials and environmentally unfriendly processes. Therefore, this study aims to utilize rice husk waste and coffee grounds as alternative raw materials for the manufacture of silica gel produced as an adsorbent.

Literature Review

Indonesia has long been known as a leading rice producing country, along with Vietnam and Thailand Indonesia is referred to as “Lumbung Padi” because it has always recorded high production totals [1]. The largest rice producing areas in Indonesia are in Central Java, East Java, West Java and South Sulawesi. A rice mill will produce about 25% husk, 8% bran, 2% rice bran & 65% rice [2]. This causes the milling waste, namely rice husk, to be very abundant every year. Rice husk is a waste from rice processing where in the rice milling process, the husk will separate from the rice grains and become residual material.

Rice husk consists of 34-44% cellulose, 23-30% lignin, 13-39% ash, and 8-15% water. Rice husk ash generally contains 86.90-97.30% silica (SiO2) and a small amount of alkali and metal impurities [3]. Silica or *silicon dioxide* (SiO2) is a sorbent of synthetic origin produced by heating silicon to 500°C.

As an unused agricultural waste, the utilization of rice husk needs attention. In addition to rice husk waste, coffee grounds are also organic waste generated from the coffee-making process [4]. Coffee is an agricultural crop that is made into a beverage from brewed coffee that has been roasted and ground into powder. Coffee is one of the commodities in the world that is cultivated in more than 50 countries. In recent years, coffee consumption around the world has increased, so the amount of coffee grounds produced is also increasing [5]. According to research conducted by [6], explained that the content of coffee grounds includes total carbon of 47.8-58.9%, total nitrogen of 1.9-2.3%, ash of 0.43-1.6%, and cellulose of 8.6% [7].

Commercial silica gel is generally produced from expensive synthetic chemical raw materials and production processes that are not environmentally friendly. Therefore, efforts to find alternative raw materials that are more economical and environmentally friendly are very important. It should also be noted that the process of natural destruction of waste is slow, so piles of waste can disturb the surrounding environment and have an impact on human health [8]. Based on this, the utilization of rice husk waste and coffee grounds as silica gel can reduce the negative impact on the environment and become a high-value product.

Research Methodologies

1. Preparation of Rice Husk Ash

The material that has been obtained enters the washing process to be cleaned of impurities, after cleaning the material is then dried in the sun until there is no more water or dry. Rice husk that has been dried in the furnace at a temperature of 650°C overnight.

2. Extraction Stage of Rice Husk and Coffee Grounds

Prepared 5 samples in the form of rice husk ash added with coffee grounds in the ratio of 100%: 0%, 75% : 25%, 50% : 50%, 75% : 25%, 0% : 100%. The sample was added 30 ml of distilled water and dripped with CH3COOH until the pH changed to 1 and then stirred continuously for 2 hours. The sample was filtered, the filtered residue was heated and added 30 ml of 1 N NaOH, then stirred again continuously. Then the sample is

filtered again, the filtrate in the form of sodium silica is set aside for the process of making silica gel.

3. Silica Gel Preparation Stage

The filtrate in the form of sodium silica is neutralized with 0.8M CH3COOH until the sample pH is 7. Then the curing process is carried out for 18 hours. After 18 hours, the sample was filtered and the filtered residue in the form of gel was washed with warm water to form silica hydrogel. Silica hydrogel was dried in an oven at 80°C for 18 hours. After drying it becomes silica xerogel. The sample was pulverized and washed with distilled water, then dried again in an oven at 120°C for 5 hours.

4. Test Results

This test aims to measure the ability of water absorption by two samples that were successfully formed, namely silica gel made from pure rice husk (sample A) and a mixture of rice husk and coffee grounds with a ratio of 75%: 25% (sample B). The test was conducted by storing the samples in a desiccator equipped with a device to measure temperature and humidity. To ensure stable environmental conditions, the desiccator was given NaCl (salt) at the bottom to maintain constant temperature and humidity. Data from the 7 day test are presented in Table 1 and Figure 1**.**

Table 1. Weight change of cup and sample during storage

Storage (day)	Weight of cup + sample A (gram)	Weight of cup + sample B (gram)
0	37,84	37,90
1	38,51	38,55
2	38,61	38,65
4	38,66	38,69
5	38,68	38,70
6	38,69	38,71
7	38,69	38,71

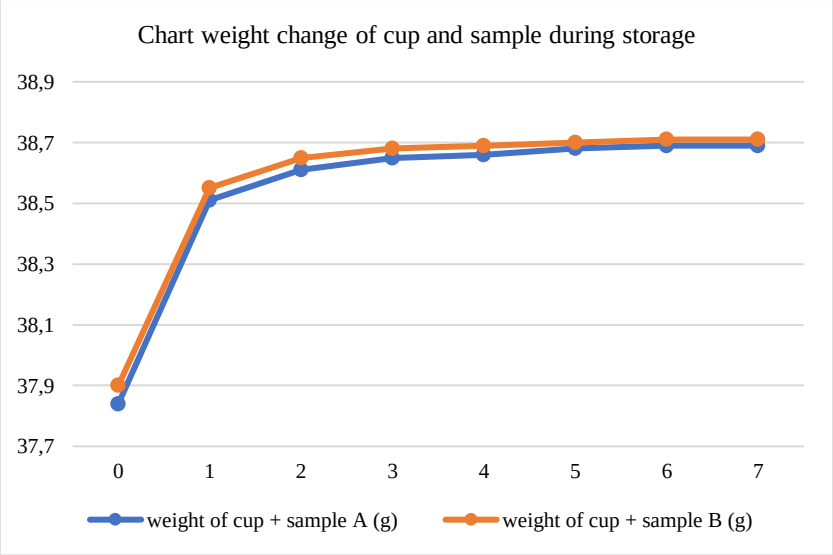

Figure 1. Weight change of cup and sample during storage

Project Practicalities

This research required easily obtainable resources, such as rice husks from a rice mill in the Makassar area, South Sulawesi, Indonesia and coffee grounds from a local coffee shop as well. The silica gel manufacturing process was carried out at the Chemical Testing Laboratory of the Department of Agricultural Technology, Pangkajene and Islands State Agricultural Polytechnic, South Sulawesi, Indonesia, which is equipped with standard laboratory equipment, including a furnace for combustion, an oven, a pH meter, and a desiccator.

The chemicals used include NaOH and CH3COOH, which are available in the chemistry laboratory. The manufacturing process takes several days, from processing the raw materials to testing the effectiveness of water absorption. Technical support from laboratory staff is required to ensure all procedures run smoothly and safely. In addition, access to additional equipment such as precision digital scales and moisture meters will assist in accurate measurements.

The implementation of this research is relatively cost-effective as it utilizes local waste, thus supporting the principle of circular economy. The processing of rice husk and coffee grounds waste into silica gel also has the potential to be replicated in other laboratories that have similar basic

equipment. With this research, it is expected to increase awareness of the importance of utilizing agricultural waste for more valuable applications.

Roadblocks and potential limitations

One of the main obstacles in this project is the limitation in maintaining consistent quality of the raw materials. The rice husk and coffee grounds used can have compositional variations that affect the final silica gel. In addition, the extraction and neutralization process requires proper pH control so that silica gel can be formed properly. Limited equipment and availability of chemicals in the laboratory can also be an obstacle, especially in the event of technical problems or the need for replacement equipment that is not available quickly.

Another potential limitation is the difficulty in setting stable environmental conditions during water absorption effectiveness testing, such as temperature and humidity. Fluctuations in environmental conditions can affect test results and reduce the validity of the data obtained. To overcome this, careful monitoring of conditions and supporting equipment such as sensitive moisture meters are required.

Post-program plan

Once this research program is completed, the next step is to develop a more efficient silica gel production method on a larger scale for industrial applications. Further research can focus on trials in various environmental conditions to evaluate the durability and performance of silica gel in the long term. In addition, collaboration with industry can open up opportunities for product commercialization, which not only reduces agricultural waste but also provides additional economic value.

Other development plans include diversifying the use of silica gel for other applications, such as moisture absorbers in the household sector or as filter media in industry. Thus, this research is expected to contribute to material innovations that are environmentally friendly and support the principle of sustainability.

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