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Adsorption of Fe(III) Ion in Tablets Fe Supplement by Black Tea Dregs and its Application in Inorganic Chemistry Learning

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Abstract

The study of the adsorption of Fe(III) ion in Fe supplement by black tea dregs has been done. This study aims to investigate: (a) the Adsorption ability of Fe(III) ion in Fe supplement by black tea dregs (b) the Analysis result of Fe(III) amounts in a sample of Fe supplement when using black tea dregs. Several parameters were analyzed, such as; water and ash contents of the adsorbent, the optimum time, and the concentration of ion Fe(III) with tea dregs in a buffer medium (pH 4,8). The analysis of sample solution concentration of Fe(III) in this study using Genesys spectrophotometry at 590 nm. The result showed that the water and ash contents were 3,03 % and 0,9 %, respectively. Small percentages indicate that the adsorbent has met the standard (SNI) 06–3730-1995. The time and concentration optimum adsorption of Fe(III)-tea dregs were 60 minutes and 100 mg/L, respectively. The result of the adsorption ability of Fe(III) ion in Fe supplement by tea dregs was 70,4% with the adsorption concentration of ion Fe(III) were 7,07 mg/L. The research results obtained can be used as teaching materials for inorganic chemistry learning, and as a reference for new materials in the field of coordination chemistry and materials.

Keywords: Fe(III) ion, black tea dregs, Fe supplement, inorganic chemistry learning

Introduction

Tea (*Camellia sinensis*) is one of the most widely consumed in the world. The tea plant originated in Southeast China, and gradually expanded to India, Sri Lanka, and further into many tropical and sub-tropical countries with areas that have sufficient rainfall, good drainage, and slightly acidic foil. Nearly 30 countries have cultivated this plant including China, India, Sri Lanka, Kenya, Turkey, Vietnam, and Indonesia (Vishnoi et al., 2018).

The types of tea that are known such as white tea, green tea, and black tea where the difference lies in the color and processing process. The color of white tea when it is brewed only turns slightly yellowish, green tea is processed without fermentation, while black tea undergoes a fermentation process (Purnami et al., 2018).

According to Hinojosa et al. (2021), the chemical composition of tea leaves is very complex, generally consisting of proteins, enzymes, amino acids, vitamins, and also phenolic compounds (such as catechins, and caffeine). Besides the compositions, tannin compounds are also founded in tea. Based on the result of research by Fajrina et al. (2016), the tannin contents in pure tea and teabags (%w / w) were 0,01207 and 0,00919, respectively. Whereas tea dregs contain celluloses (37%), hemicellulose and lignin (14,7%), and polyphenols (25%) (Purwaningsih et al., 2019).

The chemical composition and the benefits provided in tea leaves are quite a lot, including as an antioxidant, anti-inflammatory, reducing fat and obesity levels, reducing hypertension, anticancer and antibacterial (Hinojosa et al., 2021). In addition, it can reduce blood sugar levels (Setyawan et al., 2019), as an antidiarrheal (Hidjrawan, 2018), and can also be used as an adsorbent. The use of tea as an adsorbent has also been successfully carried out in absorbing heavy metals in wastewater and the results of the adsorption efficiency of Zn, Cd, Co, Pb, Cu, Fe, Mn, Ni, Cr, Hg, and As metals are 68.68- 100% (Wijaya et al., 2020).

Besides having a good effect on the body and the environment, the presence of tannin compounds in tea plays a role in reducing the absorption of iron (Fe) (Fajrina et al., 2016). According to Hallberg & Hulthen (2000), the inhibition of iron absorption by black tea is almost twice that of green tea. This is also related to the total phenol in black tea which is greater. Based on the results of research by Lina (2019), there is a relationship between the habit of drinking tea and

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the intake of iron tablets with the incidence of anemia in pregnant women, so it is recommended that when consuming tea drinks it should not be accompanied by food or Fe. The same thing has also been tested on the albino musculus balb and the results obtained are that there is an effect of giving black tea for seven days which has the potential to interfere with hemoglobin levels (Ayuni et al., 2019).

The Central Statistics Agency (BPS) reported that national tea production was 94.1 tons in 2021. This amount increased by 20.3% from the previous year's 78.2 tons. The results of tea processing in the market are packaged in various forms, not only in powder form, but also in bag form known as teabags, and be packaged in the form of drinks. However, people today prefer teabags over brewed tea because their use is very easy and practical. If you look at the large enough amount of tea production, then the waste from the tea produced will increase. Tea dregs are waste produced from tea production. One way to increase the number of tea dregs as an unused ingredient is to make it an adsorbent. Adsorption is based on the interaction of metal ions with functional groups present on the surface of the adsorbent through the interaction of the formation of complex ions (Kurniasari et al., 2020). It is reported that tea pulp can be used as an adsorbent for calcium and magnesium ions in hard water with the result that the adsorption efficiency for Ca^{2+} ions is 31.56% and Mg^{2+} is 26.28% (Kurniasari et al., 2020). When viewed in terms of the effectiveness between black tea pulp and green tea as adsorbent, black tea pulp has a better effectiveness value than green tea pulp. This has been tested to absorb Cr(VI) ions (Muhajjalin et al., 2021).

Based on the several results of the research above, researchers choose black tea dregs as a research subject to absorb Fe(III) ions that had been previously prepared from Fe supplements. The Fe(III) ion was chosen as the adsorbate starting from an experiment conducted by Bevanda (2015) which stated that the absorbtivity values of the complex formed by the interaction of tea with Fe(III) ion were higher than the Fe(II) ion. The Fe samples tested were taken from the preparation results of Fe supplements. The experiment of black tea-Fe (which is derived from the supplement) was also successfully demonstrated to teach large and small laboratory classes in two institutions, namely in the United States and Thailand (Lapanantnoppakhun et al., 2020). The experiment showed that the results of the demonstration could be used as a source of new learning material regarding the use of tea which is a natural ingredient as a binding agent for heavy metals. It is hoped that the results of this study, in addition to knowing the study of tea dregs adsorption on Fe (III) ions in iron supplements, can also be applied as learning material in inorganic chemistry courses, especially as a reference for new material in the field of coordination chemistry and materials.

Methods

This research is experimental research with a quantitative analysis method. Several of the research variables for measurements of tea dregs are to search the optimum time and optimum concentration using Fe(III) standard solution then the results obtained were applied to the adsorption of Iron supplements.

The materials used in this experiment include the black teabags which are the most widely circulated on the markets, $FeCl_3$ solution, KSCN solution, acetate buffer solution in pH 4.8, concentrated HCl solution, aquadest, filtration paper, H_2O_2 solution, Fe supplement tablets.

The types of equipment used in this experiment include Mortar and pestle agat, analytical balance, shaker (model: VRN - 480 GEMMY Orbit Shaker), pH meters (LaMotte pH 5), volumetric flask, beaker, volume pipette, electric heater, electric oven, and Genesys spectrophotometry (Genesis-10 UV specification).

Sample preparations

The powder of black tea from teabags is extracted until it does not produce a tea color and the tea dregs are dried and then the ash and water content are measured.

Twenty tablets of Fe supplement preparations were accurately weighed and ground. A portion of powder was weighed and dissolved in a mixture of 5.0 mL concentrated HCl and requested. The mixture can be filtered. The required aliquot of the filtrate was transferred to a 50 mL volumetric flask. Hydrogen peroxide (5 mL) was added, to ensure the complete oxidation to Fe (III).

Determination of adsorption optimum time of Fe(III) ion by black tea dregs.

To determine of adsorption optimum time of Fe(III) ion by black tea dregs 0.2 gram of tea dregs was mixed with 50 ppm of Fe(III) standard solution at pH 4.8 condition. The contact time values varied from 0, 15, 30, 45, 60, and 90 minutes. They were filtrated and the filtrate was mixed with KSCN solution. The concentrations of Fe(III) ion was analyzed using Genesys spectrophotometry at maximum wavelength.

Determination of adsorption optimum concentration of Fe(III) ion by black tea dregs.

To determine of adsorption optimum concentration of Fe(III) ion by black tea dregs 0.2 gram of tea dregs was mixed with Fe(III) standard solution at optimum pH and contact time conditions. The concentrations values of metal ions varied from 20, 30, 40, 50, 100, 150, 200, 250, and 300 mg / L. They were filtrated and the filtrate was mixed with KSCN solution. The concentrations of Fe(III) ion was analyzed using Genesys spectrophotometry at maximum wavelength.

Application of adsorption Fe(III) in supplement tablets by black tea dregs.

To determine of adsorption Fe(III) in supplement tablets by black tea dregs 0.2 gram of tea dregs was mixed with supplement Fe(III) sample at pH 4.8 and contact time conditions. They were filtrated and the filtrate was mixed with KSCN solution. The concentrations of Fe(III) ion in supplement samples before and after adsorption by black tea dregs were analyzed using Genesys spectrophotometry at maximum wavelength).

Results and Discussion

Utilization of tea dregs as adsorbent because it contains a lot of cellulose compounds (37%) which can adsorb metal ions with adsorption ways because have carboxyl and hydroxyl groups (Purwaningsih et al., 2019). In this study, black tea dregs were chosen because consumption of black tea is more widely used, so the tea dregs that are no longer used can be used as adsorbents, besides aiming to increase the quantity of the dregs, they can also be used as an alternative to reduce waste from tea dregs. In addition, based on the results of research by Muhajjalin et al. (2021), the adsorption effect of black tea dregs is better than green tea dregs as an adsorbent.

Before being applied as an adsorbent, the dried tea dregs were tested for water and ash contents to find out whether the adsorbent had qualified for (SNI) 06–3730-1995 standard. The SNI standard for water contents is a maximum of 15% and ash contents are a maximum of 10% (Laos & Selan, 2016). The measurement result of water contents for the adsorbent is 3.03% meaning that at least is left behind and covers the surface of the adsorbent (Rahayu & Adhitiyawarman, 2014). While the ash content of the adsorbent obtained is 0.9%, meaning that the presence of slightly less ash cause pore clogging so that the surface area for adsorption is greater. This indicates that the tea dregs adsorbent used in this study had qualified for (SNI) 06-3730-1995 standard.

Determination of maximum wavelength

Determining of maximum wavelength is needed in chemical analysis, especially using genesis spectrophotometry. Based on **Figure 1** are shown the maximum wavelength of tea dregs-Fe(III) adsorption was attained at 590 nm.

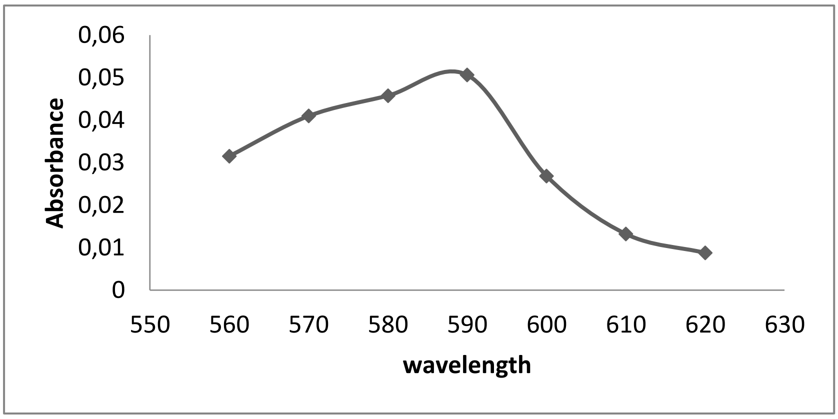

Figure 1. Determination of maximum wavelength of tea dregs-Fe(III) adsorption

Determination of adsorption optimum time of Fe(III) ion by black tea dregs.

Determine of adsorption optimum time of Fe(III) ion by black tea dregs has been done with contact time values varied from 0, 15, 30, 45, 60, and 90 minutes. Based on the experiment results were obtained at 60 minutes. This is because, at the beginning of the adsorption, there are many empty spaces on the surface of the adsorbent that will bind heavy metal ions so that the adsorbent has sufficient time to bind to heavy metal ions which results in the adsorption process running fast (Wijaya et al., 2020). This lasts until the surface is saturated and this is observed at a time of 60 minutes, then after that time, the activity of adsorbent adsorption in adsorbing the ion decreases (**Figure 2**). With a significant decrease in adsorption capacity after 60 minutes, the possibility that metal cations that have been bound to adsorbent can come off again. This is known as desorption. Desorption occurs due to the saturated surface of the adsorbent. In the saturated state, the rate of adsorption is reduced so that the contact time no longer has an effect (Irwandi et al., 2015).

Determination of adsorption optimum concentration of Fe(III) ion by black tea dregs.

The optimum concentration of Fe(III) tea dregs has been determined. The experiment was carried out as stated above by varying the metal ion concentration from 20, 30, 40, 50, 100, 150, 200, 250, and 300 mg / L. Based on the experiment, the optimum concentration was obtained at 100 mg/L (**Figure 3**)

The increase in the number of Absorbed Fe(III) ions as the concentration increases to a concentration of 100 mg / L is caused because at low concentrations all metal ions can still interact with active sites in adsorbents so that the removal process still increases (Jeyaseelan & Gupta, 2016). However, after a concentration of 100 mg/L, there was a decrease in adsorption power due to the limited number of empty active sites on the surface of the adsorbent that can be occupied by adsorbate (Gupta & Balomajumder, 2015).

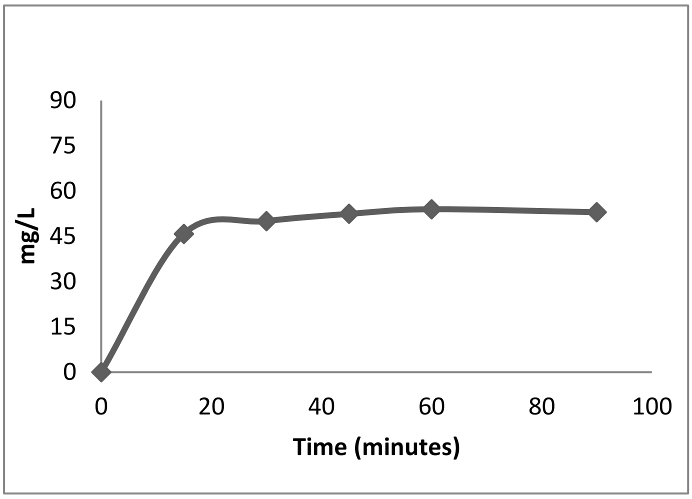

Figure 2. Determination of adsorption optimum time Fe(III) ion by tea dregs

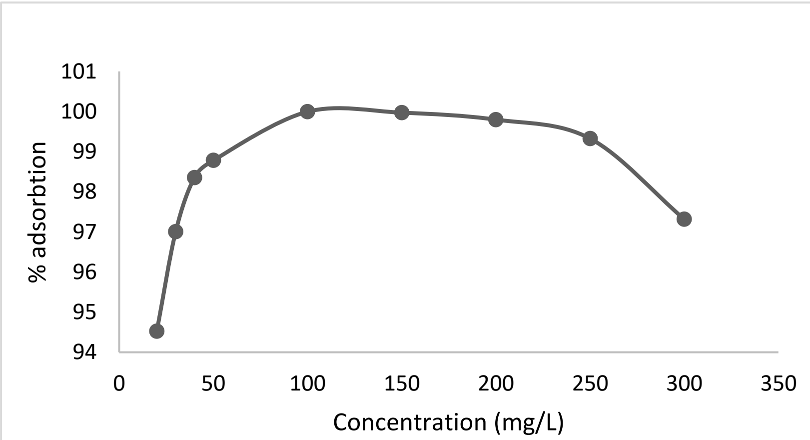

Figure 3. Determination of adsorption optimum concentration Fe(III) ion by tea dregs

Application of adsorption Fe(III) in supplement tablets by black tea dregs

The application of the adsorption of Fe(III) ions by tea dregs in the supplement was initiated by repairing the tablet sample to obtain Fe(III) ions. Furthermore, knowing the contents of Fe(III) ions before the adsorption process and the results obtained are 10.03 mg / L. The adsorption process was carried out by adding black tea dregs to the adsorbate at the maximum time and pH of 4.8. The results obtained that the contents of Fe(III) after being adsorbed was 2.97 mg / L. This shows that tea dregs can be used as an adsorbent because the amount of % adsorbed for Fe(III) ions is 70.4% with the amount of Fe(III) ions absorbed being 7.07 mg/L

Application in inorganic chemistry learning

Adsorption is one of the simple methods used as a way to remove heavy metals, in this case, namely Fe(III) ions. Adsorption is based on the interaction of metal ions with functional groups present on the surface of the adsorbent through the interaction of the formation of complex ions (Kurniasari et al., 2020). Complex ion matter is a material that is widely discussed in the field of Inorganic chemistry, especially in coordination chemistry and materials. The adsorbent used can use materials and natural materials that have compounds that play a very important role in the binding of metal ions. In this study, the adsorbent used to bind Fe(III) ions was tea pulp. The ability to bind Fe(III) ions is because tea pulp contains cellulose (37%). Two functional groups of cellulose are hydroxyl and carboxyl which play a role in the binding of Fe(III) ions. (Purwaningsih et al., 2019). This has been proven by the research results obtained. The results of this research can be used as learning material in inorganic chemistry courses, especially as a reference for new materials in the field of coordination chemistry and materials.

Conclusions

Based on the data analysis results, the conclusion of this research is the tea dregs from black tea can be used as an adsorbent for Fe(III) ion in Fe supplement. The adsorption ability is 70.4% and the amount of Fe(III) ion adsorbed is 7.07

mg/L. In addition, the time and concentration optimum of Fe(III) black tea dregs were 60 minutes and 100 mg/L, respectively in a buffer medium (pH 4.8). The results of this study indicate that there is an interaction between tea dregs and Fe so that it can be used as a reference that can be applied in inorganic chemistry learning, especially in coordination chemistry and inorganic materials.

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