Journal of Industrial and Engineering Chemistry 20 (2014) 3089–3095

Contents lists available at ScienceDirect

Journal of Industrial and Engineering Chemistry

journal homepage: www.elsevier.com/locate/jiec

Preparation of spherical foamed body with function of media for waste water treatment by using waste LCD glass

Chul-Tae Lee *

Department of Chemical Engineering, Dankook University, Gyeonggi 448-701, Republic of Korea

ARTICLE INFO

Article history:
Received 27 August 2013
Accepted 12 November 2013
Available online 17 November 2013

Keywords:
Waste LCD glass
Recycling
Foaming
Spherical foamed body
Water treatment media

ABSTRACT

Using waste LCD glass as a base material helped developed the manufacturing process of the spherical foamed body and its varied functionality. Also, the manufactured spherical foamed body showed great performance as a water treatment media. By mixing 90 wt% of waste LCD glass, 100 parts by weight of glass mixture that has 10 wt% kaolinite as a shaping agent, 1.0 part by weight of carbon foaming agent, and mixture of each 1.5 parts by weight of Na_2CO_3, $CaCO_3$ and Na_2SO_4 as foaming agents and the MgO as a parting agent for 10 min of foaming calcination in the rotary kiln at 970–1000 °C, the spherical foamed body can be manufactured effectively. The manufactured spherical foamed body performed as a great water treatment media by showing 70.5% of SS removal efficiency, 56.1% of BOD removal efficiency, 57.5% of COD removal efficiency, 28.6% of denitrification and 49.8% of phosphorous removal.
© 2013 The Korean Society of Industrial and Engineering Chemistry. Published by Elsevier B.V. All rights reserved.

1. Introduction

TFT-LCD panel is the monitor screen that is composed of a liquid crystal between two sheets of glass. This LCD panel contains toxic materials such as mercury which can be found in CCFL (cold cathode fluorescent lamp), industrial materials such as glass and plastic and rare metals such as indium and tin. Therefore, an efficient recycling strategy for waste LCD panel is a very important issue environmentally and economically [1–3].

Before the 21st century, disposal of toxic material from waste LCD panels was considered to be the main problem. So, the traditional ways such as heat treatment, ultrasonic waves and chemical method were utilized for disposal of a waste LCD panel [4]. Recently, due to increase usage of rare metals, retrieval of valuable metals such as indium and tin is becoming an important factor of the recycling process [5–8]. The important material that needs to be handled during the final stage of the recycling process of TFT-LCD panel is waste LCD glass which weighs around 40–50% of the panel's weight. Disposal of waste LCD glass is categorized to several types based on different recycling processes. First, after removing the backlight lamp and retrieving the plastic and the circuit board from the waste LCD panel that has been used, the waste LCD glass with no or partial ITO film attached is called "type A waste LCD glass". Also, after removing ITO or rare metal by using acid or alkali, the waste LCD glass that is in the condition of slurry is called "type C waste LCD glass". On the other hand, there are tons of defective LCD glasses that were manufactured from the production line of the LCD panel factory and these kinds of waste LCD glass are known as "type B waste LCD glass". Basically, type B waste LCD glass is similar to type A waste LCD glass, but it is physically and chemically different when it is compared to type C waste LCD glass which is treated with acid or alkali to retrieve indium, tin and other rare metals. On the other hand, the leftover glass material that was not used before manufacture of LCD panel known as "Bare glass" is called a "type D waste LCD glass". Type B waste LCD glass and the waste LCD glass from the LCD panel that is manufactured after 2009 do not cause any problems for recycling, however, the waste LCD glass from the LCD panel that is manufactured before 2009 requires careful treatment during recycling because it contains toxic materials such as Sb_2O_3 and As_2O_5. Currently, there are three suggestions for waste LCD glass recycling solution: (i) reuse after removing impurities [9–11], (ii) complex usage in metallurgy, melting, incineration, cement manufacture and high-temperature eutectic [12–16], (iii) use as a material for manufacturing tile [17,18]. However, those suggestions are not the solutions for every type of waste LCD glass and due to lack of technology and economic feasibility, currently, most of the waste LCD glass is buried in landfill regardless of the type of waste LCD glass. Due to increase of transfer cost and lack of landfill, this method cannot solve the actual problem and does not follow EU's WEEE regulation which requires a retrieval rate of at least 75% and a recycling rate of 65%

* Tel.: +82 31 8005 3541; fax: +82 81 8005 4057.
E-mail addresses: chult823@dankook.ac.kr, ctlee823@hanmail.net

1226-086X/$ – see front matter © 2013 The Korean Society of Industrial and Engineering Chemistry. Published by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jiec.2013.11.048

for electronic products [19]. Therefore, the solution for efficient recycling of waste LCD glass is essential for the company and nations' international competitiveness. According to the article [20–22], waste LCD glass' physical and chemical characteristics were researched to find if foamed waste LCD glass can be used as a material of foamed borosilicate glass for the structural or chemical process. In addition, the differences such as difficulty of foaming process were researched based on different foaming processes for different types of waste LCD glass.

Based on the result of the articles, in this study, a manufacturing process of the spherical foamed glass bead made of waste LCD glass as a material was researched which enables the possible development of various applications. In addition, the potential of other applications was studied by applying manufactured spherical foamed glass beads as a water treatment media.

2. Materials and methods

2.1. Preparation of the waste LCD glass and materials for foaming process

In this study, type B waste LCD glass was used for manufacturing spherical foamed glass bead. Waste LCD glass materials from the LCD panel manufacturing factory were finely ground and used as glass materials without any additional treatment. Based on the results of the article [21,22], for the grinding process, a ball mill with an alumina ball was used and the size of the grinding particle was designed to be less than 44 μm. Also, based on the article [21,22] carbon material from carbon black or natural graphite was used as a foaming agent with the particle size of less than 44 μm. Metallic salts such as Na_2CO_3, $CaCO_3$ and Na_2SO_4 were used as foaming agents and the sizes of the particle was designed to be less than 44 μm as well. In order to manufacture spherical foamed beads, the mixture of materials has to be spherical shape in order to get processed in a rotary kiln. Therefore, for the shaping agent, finely ground kaolinite which has the size of less than 44 μm was used, and for a stabilizer, first class reagents SiO_2 and B_2O_3 were used.

2.2. Chemical composition of finely ground waste LCD glass material

Chemical compositions of waste LCD glass are slightly different based on different panel manufacturing companies, and those differences in chemical compositions of glass materials critically affect the foaming process [20–22]. Therefore, this study suggests a way to minimize the influence that can be caused by chemical compositions of waste LCD glass. In this study, chemical compositions of finely ground waste LCD glass showed Borosilicate aluminum glass which is composed of 63–68 wt% of SiO_2, 10–18 wt% of Al_2O_3, and 3–10 wt% of B_2O_3 3–10.

2.3. Manufacture of the spherical foamed glass bead

Waste LCD glass powder that has the particle size less than 44 μm was mixed evenly with carbon material or Metallic salts such as Na_2CO_3 and the shaping agent. By using a disk type granulator, the waste LCD glass mixture was turned into a spherical shape. After turning into the spherical shape, the waste LCD glass mixture was dried for 4–5 h at room temperature in order to remove moisture on the surface of the body. Then, with powdered MgO, the parting agent, the waste LCD mixture is put in the rotary kiln with a preheat phase of 500–700 °C, 850–1050 °C of foaming calcination phase and 550–650 °C of quench phase. Since the size of the foamed body is less than 1 cm of spherical shape and much smaller than other usual foamed glass, the spherical foamed glass bead can be annealed and stabilized at the same time without any additional stabilization phase. The annealing process starts from 400 °C until room temperature. Then, the mixture was taken out from the rotary kiln, and the spherical foamed glass was separated from the parting agent. Finally, the spherical foamed glass was produced successfully.

2.4. Analysis of spherical foamed waste LCD glass

Every chemical and physical test to find out the properties of the spherical foamed body such as compression strength and density was carried out based on ASTM standard, KS standard or ISO standard. Other material properties were analyzed by common scientific method and theoretical calculation. Since the manufactured foamed body had a spherical shape and such a small size which was around 10 mm, it was difficult to measure the correct density. Therefore, packing density and floating ratio were measured for the foamed condition.

2.4.1. Packing density

Spherical foamed bodies were filled in a 500 ml mass cylinder and the mass of that volume was measured to calculate the packing density. Packing density can be an important factor to find the foamed condition.

2.4.2. Floating ratio

In this study, actual density is significant because the inorganic spherical foamed body can be used as a light-weight agent or water treatment carrier. Floating ratio was calculated as the ratio of mass for some foamed bodies that float on the water to the mass of all foamed bodies that were put in the water.

2.5. Manufactured spherical foamed body's performance test as a water treatment media

Manufactured spherical foamed body was tested to see if it can work as water treatment media. Water from a nonpoint pollution source was filtered by the spherical foamed body and the filtered water was analyzed. The experiment and analysis of filtered water was carried out based on KS standard or ISO standard.

3. Results

3.1. Selection of shaping agents

In order to manufacture the spherical foamed glass bead, the process has to be carried out in a rotary kiln. Then, in order to manufacture the spherical foamed body, the mixture of waste LCD glass, carbon foaming agent, metallic salt's foaming agent and other additives have to be shaped into a spherical shape with the use of a shaping agent before being placed into the rotary kiln. Shaping agent affects the foaming mechanism which might lead to some errors in foaming calcination, but it is important since it can control the shape of the foamed body that the user wants and how the foamed body will be used. Therefore, the proper bonding agent should be selected depending on the purpose of the light-weight agent, water treatment media or other various agents. Also, based on the shaping agent, it is possible to control the density of the spherical inorganic foamed body to be 1 g/cm^3 or any density in the range of 0.3–0.9 g/cm^3.

Based on the researches from various papers, starch, PVA, kaolinite and basalt were tested as possible shaping agents. First, the waste LCD glass powder with particle size of 44 μm was mixed evenly with 0.3 wt% of carbon black as the carbon material foaming agent and 10 wt% of each chosen shaping agent. Then, the mixture was shaped to be spherical by using a disk type granulator and was put in the rotary kiln at 950 °C for 10 min which is the required

Download English Version:

https://daneshyari.com/en/article/227375

Download Persian Version:

https://daneshyari.com/article/227375

Daneshyari.com