Xournals

Academic Journal of Material Sciences

ISSN UA | Volume 01 | Issue 01 | January-2019

Utilization of Waste Borosilicate and Cathode Ray Tube (CRT) Glass

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Available online at: www.xournals.com

Received 25th August2018 | Revised 10th October 2018 | Accepted 10th December 2018

Abstract:

Ground Soda Glass (SG) is used as additive which is a blended mixture of orthoclase feldspar, grog and quartz. These three types of local clays are taken from different sites. All raw materials include soda glass that is fully assessed thermally, chemically and mineralogically. For studying, the sodas glass was containing in gradual proportions with the effect of its contribution on the physical properties of the required fired samples which includes bulk density, water absorption and apparent porosity. The waste glass was used for the formation of glaze which is setup because of the absence of required fluxes for the formation of low temperature translucent glaze that are found in excessive amount in the form of waste which are thrown out because of its pollutant property. This paper discuss about the accessibility and use of particularly waste glasses for the formation of translucent glazes by the process of sieving the waste glass into fine particles known as cullet and recycling of cathode ray tube (CRT) glass waste.

Keywords: *Soda Glass (SG), Cullet, Glaze, Cathode ray tube (CRT)*

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Introduction

In generally, ceramics products are formed from the natural occurring resources i.e., alumina, clay, feldspar, calcium carbonate, silica etc. The demand of the ceramics products are increasing day by day because of human activities. In the ceramic products, bone china crockery, glazed ceramics tiles are included. In ceramic products, silica plays a very important role at biscuit and shine temperature since it works as a principle material and converted into glassy state. At the time of production of glass, the basic principle of raw material is applied in silica due to which different forms are produced like silicates and after applying the high temperature, it melts and gain shape. During melting process, several compounds are added like fluxes work as a catalyst at low temperature due to which the reaction is accelerate and melt quickly. There are many steps such as manufacturing process of ceramics, in which raw materials are mixed thoroughly and form bodies and glaze. After firing, the interaction occurs between bodies and glazes by which attractiveness and properties are produced which make it useful to man in their life. In the same way, these types of raw materials are mined and used for the production of glasses. The waste glasses are also used in the formation processes and cullets technique is used as the waste glasses are grind into crushed fine grains.

In order to optimize consumption of natural resources, recycling the products and preventing pollution from the disposal of such waste. Recycled glass can come from several sources such as glass bottles, television screens, flat glass, light-bulbs etc. and before it can be used in ceramic tile manufacturing, it would provide characteristics such as supply needs to be plentiful and its composition must be both homogenous and constant. The most types of glass are formed by network-forming oxides and network-modifying oxides which is calcium oxide, silicon oxide and sodium oxide. Glass contain the amorphous nature and also its composition (rich in alkalis) give it a fluxing character because of its properties, recycled glass can be used in ceramic engobe, ceramic body compositions and glaze compositions as a suitable for frits.

Glass characteristics

For homogeneity, recycled waste glass was analyzed in which recycled sodium-calcium glass, flat glass which is most widely available and could offer the ceramics sector. Besides, to formulate the glazes, waste borosilicate glass, although less widely available, was used. The recycled flat glass waste consist of morphological and micro-analytical characterization that are analyzed through scanning electron microscopy (SEM) and X-ray microanalysis.

Table: Percentage of glaze raw material

Raw material	Weight percentage
Zinc oxide	1.08
Quartz	3.24
Calcite	14.02
Potash Feldspar	21.57
Zircosil	9.71
Opaque Frit	25.89
Talc	3.61
Wollastonite	3.61
Calcined Alumina	6.47
China clay	10.79

Cullet is defined as waste broken glass having the major components used for the preparation of glaze. When glaze has low thermal extension and higher alumina content, it is considered as special kind of glass that differs from glass ware and window glass. The low thermal extension and alumina increase its viscosity and help in adhering with the clay body. The Cullet materials consists sodium, silicon, and calcium oxides, also known as soda-lime silica glass with magnesium and aluminum oxide in small quantity. While is flux is those compounds which have lower melting point of glaze and those having low melting point after mixing with silica form a glassy crystal.

The waste materials from appliances including Cathode Ray Tube (CRT) that taken from electronic appliances like computer, television etc. The current CRT technique will not be used if digital TV is introduced. Due to changes in broadcasting and technical program, the demand of CRT is being increased. Through the waste glasses recycling, CRT are produced as a raw material. In the future, the recycling process of CRT will disappeared and then

there would be need of new alternative techniques to treat the waste CRT. For recycling technique of waste CRT face problem as lack and decreasing the demand of wasted CRT glass that include Zinc and other heavy metals. Other commercial techniques are capable to recycle waste CRT glass and produce the other new products.

Overview of ceramic glass

Glaze has objectives, through the better knowledge and understanding of glazes' materials and their properties, we are able to use the glaze with vast applications. Actually, it is a mixture of borates and silicates, applied on the products of ceramics before the heat treatment to produce fine, glossy material. There will be no glaze without silica and glass formers are boron, silicon and phosphorous. In three dimensions, an unplanned networks of silica and oxygen without any regular repetition produce thee structure of pure silica glass. These silica structure bonds are very strong and to break these bonds for melting, there is need of high temperature. In some cases, silica also refer to as Flint that is important glaze element, also called as quartz, have pure crystalline form. In glass structure, silica is considered as the network former whereas fluxing oxides as network modifier because it breaks the bond between silica and oxygen and therefore lowering melting temperature.

Borosilicate Glass

Borosilicate glass is a kind of glass, having the constituents of boron and silica oxide. Borosilicate glasses have very low thermal extension (~5 × 10−6/°C at 20°C), which make them resist to breakdown due to thermal effects compared to other types of glass. Borosilicate glass is formed chiefly from boric (7-13%) and silica oxide (70-80%) with alkalis (sodium and potassium oxides) and aluminum oxide in small amounts. Because of the low quantity of alkali, this type of glass has better chemical and thermal stability (after changing the temperature, it resist and doesn't break). So, it is broadly used in the chemical industry, as laboratory apparatus and other pharmaceutical ampules. In glass making, by addition of quartz, carbonate of sodium and calcium, boron is used to manufacturing the borosilicate glass which is affect it properties for a preferred use. In low temperature ceramic glazes, boron is a very strong flux and performs the same function in glass production.

Borosilicate glass composition:

- Silica- 70%
- Boron oxide- 10%
- Potassium oxide -8%
- Sodium oxide- 8%
- Calcium oxide (lime)- 1%

Material Experimentation and Processing

With cullet, avoid the mixture of other impurities and care should be taken in the process of injection vial to convert into cullet which is done by washing the glass to remove the dirt and impurities in cullet. Then, dried the cullet and grind and ball are crushed for several hours for making the finest glass powder after sieving.

Test Tiles Formation

On the surface of tiles, green ware were made only to examine the behavior of glaze. Before it was placed in kiln, it should be allow to dry. For escaping the moisture, the spy hole are left open.

Glaze Composition in Biaxial Blend

Glaze are formed from wasted borosilicate glass which have silica and flux, an important materials for glaze, For the determination of best ratio at which glaze is formed by the mixing of cullet and other material, biaxial blend of glaze composition are adopted.

During composition, following factors were strictly adhere:

- By using three beam balance, cullet was accurately measured
- Cullet is mixed with the other combining material during the addition of water and sired very well for full mixing.
- Mixing of any kind should be avoided, when every composed blend was considered.
- For proper accuracy, also labelled the every produced test tiles after firin.

Recycling technique

Firstly, recycling technique is selected for applying on CRT waste that promote the recycling plan and then, final techniques is selected by property on the matter, consultation, visiting, self-review and then the evaluation of CRT.

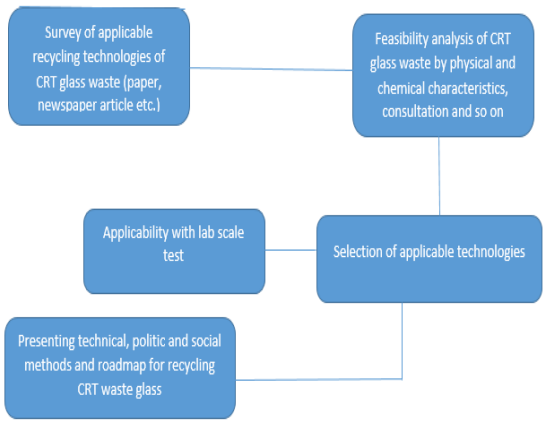

Figure: Overview on Recycling CRT glass waste

Characteristics of CRT glass waste

Main raw material and supplement raw material are separated by glass raw materials. Leading raw material including silica, magnesia, boric acid, alumina, lime etc. that are the chief constituent of glass but in additional fresh materials used of emulsifying concentrate, clarifying agent, reducing agent, flux, oxidizing agent, coloring agent, decolorant etc. existing in lesser amount which are supplementary to give different feature to glass.

For the purpose of comparison of the properties of CRT glass left-over and other misused glass in which CRT glass waste distinct the panel and funnel, then distinguishes less than 200µm XRF (X-Ray Fluorescence) examination was executed. Low melting catalyst component like K2O, Na2O is panel of CRT glass waste contrasting to the bottle and plate glass consisting 10% BaO constituent (for basic refraction of the optical glass). Funnel has various features as 20% PbO that were exceptional for index of refraction, dispersability and breaking. It is necessary to be parted from the panel because of the danger of leakage at the time of recycling.

Technologies selection for CRT glass waste recycling

Using existing technologies, leftover glass can be reused like cement bricks, road filler, light forming ceramic, container glass, clay bricks, glass wool, glazing, glass beads, sheet glass, lead smelting and many more. The technologies of recycling that consist glass beads CRT tube, tile, artificial marble based on heavily imports. For the purpose of recycling CRT waste glass export with the reason of supposition is recognized so strongly used to left-out CRT glass. For container glass, CRT glass and sheet glass waste was utilize as less important raw materials that altered things of formed glass will drop worth of new glass. It is difficult to apply in circumstance of road filler since CRT glass waste recycling law does not occur.

Evaluation and Applicability of wasted CRT glass as clay brick and cement brick

This type of glass was estimated by construction cement block and clay bricks but by means of only panel since CRT's funnel has the potential of producing lead lechate. The method of making clay bricks was mixing of fresh material, molding and compression and lastly include drying and firing. CRT glass and clay are utilizes element size that is less than 200µm. With the use of drying temperature of approximately 100℃ for moreover duration of 15 days and temperature of firing consisting 1,000℃ for atleast duration of 24 hours for avoiding cracks of clay bricks. Creation of method of cement bricks was mixing of raw material, molding, curing, compression and drying. For the manner of sand replaced CRT glass, stone powder and CRT glass particle size was consider i.e. 1-4mm, including drying and curing temperature was approximately of 20℃ with the duration of 15 days.

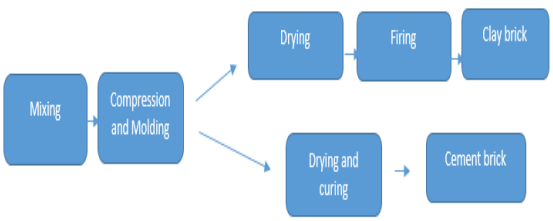

Figure: Manufacturing process of cement and clay brick

When CRT glass waste was applied, then contain most significant issue was classification of grain size. Cement brick, glass wool and lead smelting are consisting size of certain centimeter and clay brick

was size certain millimeter. Glaze was measured to some specific micrometer and hence was applicable to the CRT glass waste of the present process. From recycling center, CRT waste glass was at large to discrete funnel and panel. The CRT glass left-over valuable rate to difference the present fresh material of individual reutilizing method.

Review of Literature

Bhattacharyya, Das and Mitra 2005, concluded that typical triaxial porcelain body either in absence or presence of Titania showed optimum physical properties and maximum strength at 1300°C following which properties deteriorated. Due to excess formation of glassy phases, TiO2 containing samples has more pronounced effect. As major phase, XRD results established the occurrence of mullite and quartz. Due to the excess glass formation, the content of quartz reduced with increment of content of TiO2 content and at the same time closure whereas the content of mullite content increased in TiO2 content.

Bragança et.al 2006, discussed about the production of white ware bodies with interpretations consisting foundry sand, glass waste and white-firing clay. The value of compelled ceramic bodies was worth enough for the making of earthenware, porcelain and faience. The large quantities of glass waste directed to lesser water absorption (WA), when linked with ceramic bodies organized from formulation of porcelain (FP) fired at 1200°C, building it probable to come across the mechanical specifications of porcelain. In density, there was no significance difference of originations with content of foundry sand that can be as higher up to 45% in the triaxial ceramic mass. For firing temperature that is between 1200 and 1250°C, greater densification later firing was attained and the quantity of flux added was more essential than variation found in content of foundry.

Caki, Kaya and Günhan 2013, stated that by using glass waste, varying colors and surface textures were obtained such as ulexite, sodium feldspar and potassium feldspar in the alkaline and boron added standard stoneware glazes. In the transparent glazes, there is no colorant addition and in crackle surfaces, glass waste concentrations resulted found. Significant differences are observed in color of glaze in case of copper and cobalt oxide additions into glaze glass. As melting materials, glass left-over can be utilize in raw stoneware glazes and it utilize for the purpose of various compositions of body and composition of glaze consisting high alkaline content by using benefits in color things to generate mechanism with an creative manner.

Fadaly and Enany 2015, stated that for temperature, leadless glaze for low temperature firing has been developed and these glaze are composed from clay 65:80% and frit 20:30%. Frit is based on borax, feldspar and sodium bicarbonate that as fluxing agents. At firing temperatures that in the range 800-950ºC, matt surface of glazed ceramic cooking ware was obtained. By measuring constants of thermal expansion of glaze and body as well as thermal shock resistance, thermal compatibility of ceramic cooking ware and glazes are confirmed. In acetic acid 4%, ceramic glaze played an important role in zinc and lead that released leached at room temperature after 24h. The amount of extracted lead and zinc are less than 1 mg/l compared with uncontrolled one in local market 28 mg/l but not determined cadmium in all.

Kalirajan et.al 2016, dictated that on the development of microstructure and crystalline kinetics, influence of glass waste that is examined in zircon dependent on glass-ceramic glaze. It contain part of glass waste which have around different three percentages of tube light and borosilicate glass waste are particular and supplementary as one of elements in the composition of standard opaque glaze. The patterns of XRD show the occurrence of zircon crystal as the chief crystalline phase alongside with minor crystalline phases like diopside and wollastonite. By scanning electron microscope (SEM), it can be estimated that from the structure of microstructural examination that comprise to a certain extent amount of pores on glazed surface and also usual size of zircon crystal is decreased from 960 to 440nm. Due to increase in viscosity of glassy melt, decrement in the crystal size that is accomplished.

Conclusion

Borosilicate and cathode ray tube glass (CRT) play an important role in waste utilization to form the new things such as transparent glaze, cement bricks and clay brick etc. In which glazes formed from cullet with connection of any other required fluxes. At low temperature, there is formation of non-crawling or running glazes or non-crazing from cullet. Borosilicate glass formed crucial conclusion when utilize for the purpose of silica/flux as related with other type of resources which positioned with the help of soda-lime silica glasses in creating ceramic

glazes. With KS standard, clay brick lab-scale test and cement brick both example are fulfilled. At existing technology, CRT glass waste apply recycling, section and funnel are needed to distinct noticeably.

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