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

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Abstract:

Ground Soda Glass (SG) was utilized as an additive to a well-blended mixture composed of orthoclase feldspar, grog, quartz and these three types of local clay's taken from different sites. All used raw materials including soda glass that were fully assessed thermally, chemically and mineralogically. In order to the study of sods glass was added in gradual proportions with the effect of its addition on the physical properties of fired samples (water absorption, bulk density and apparent porosity). The waste glass was used for the forming of glaze and these glaze was setup due to unavailability of required fluxes for formulating a workable low temperature transparent glaze that are found to be abundantly available as waste, which are discarded because it is immediate act pollutant. In this paper, discuss about the availability and utilization of particularly waste glasses for formulating transparent glazes by processing and sieving waste glass into finest particle called 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 made of naturally occurring materials such as feldspar, alumina, calcium carbonate, clay, silica etc. For day by day activities, increase in population demand a large quantity of ceramic products (sanitary were products, bone china crockery, glazed ceramic tiles etc.). In ceramic products, silica is found to be very important both at biscuit and gloss temperature since it forms the principal material needed for sintering or conversion to glassy state. The principle of raw material was used in silica during production of glass that comes in several compounds of silicates and at high temperature, it is melted and formed to shape. At low temperature, it is with addition of several compounds called fluxes a catalyst that accelerates the melting temperature of silica. It contain manufacturing process of ceramics that consist excavation of raw materials which is mixed together in different ways to form bodies and glazes. After firing, these interaction of bodies and glazes which brings about its attractiveness and properties that make it useful to man in every ramification of life. Similarly such raw materials are excavated and used for glass processing and production. The waste glasses formation processes are used and cullets are recycled for further production 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 was carried out using 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 that contains major materials required for glaze preparation. In its lower thermal expansion and higher alumina content, glaze is as a special sort of glass that is differing from window –glass and glass ware which is increase its viscosity and help it to adhere to clay body. Most cullet consists of silicon, sodium and calcium oxides (that is referred to as soda-lime-silica glass) with minor components such as magnesium and aluminium oxides. But Flux term is applied to those compounds that contain lower melting point of glaze and many chemicals with low melting point will also readily combine with silica to form a glassy crystal.

The waste materials from appliances including Cathode Ray Tube (CRT) that taken from television and computer is rapidly increasing globally. The current CRT technique will not be used if digital TV is introduced. New CRT technique demand is continuously decrease in case of TV and computer for broadcasting and technical change. On waste glass, demanding of mainly recycling to produce a new CRT as raw materials. These recycling will be disappeared and remained waste CRT needs to be treated by alternative technologies. For recycling technique, main obstacle of wasted CRT recycling is lack and decreasing the demand about wasted CRT glass that include lead and other heavy metals. Other commercial techniques are able to recycle waste CRT glass into other products.

Overview of ceramic glass

Glaze has objective that at a better knowledge and understanding of glazes materials and their properties and widening the art of glaze usage and applications. It is define as a glass differing from window-glass and glass ware in its higher alumina content and lower thermal expansion that increase its viscosity and help it to adhere to the body. Glaze is a mixture of silicates and borates which is applied on ceramic products before heat treatment to produce glossy-smooth or matty finish as desired. There will be no glaze without silica and glass formers are boron, silicon and phosphorous. In three dimensions, structure of pure silica glass is thought to be a random network of silicon and oxygen continued indefinitely without any regular repetition. These structure solid bonds are very strong and certainly require a very high temperature to loosen it bonds and make it melt. In some cases, silica also refer to as Flint that is essential glaze ingredient and also known as quartz in its pure crystalline state. In glass structure silica is regarded as the network former while fluxing oxides as network modifier because they break silicon-oxygen bond and therefore lowering melting temperature.

Borosilicate glass

Borosilicate glass is a type of glass with the main glass-forming constituent's boron and silica oxide. Borosilicate glasses are known for having very low coefficients of thermal expansion (~5 × 10−6/°C at 20°C), making them resistant to thermal shock, more so than any other common glass. Borosilicate glass is made chiefly of boric (7-13%) and silica oxide (70-80%) with smaller amounts of the alkalis (sodium and potassium oxides) and aluminium oxide. This type of glass has relatively low alkali content and subsequently has good chemical durability and thermal shock resistance (doesn't break when changing temperature quickly). As a result it is widely used in the chemical industry, for ampoules, for laboratory apparatus and other pharmaceutical containers. In glass making, by addition of quartz, sodium carbonate, and calcium carbonate and boron is used to manufacture of 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 is about:

- 70% silica
- 10% boron oxide
- 8% potassium oxide
- 8% sodium oxide
- 1% calcium oxide (lime)

Material Experimentation and Processing

With cullet, avoid the mixture of other impurities and took care in processing the injection vial to cullet and it was done thorough washing of glass so as to remove every dirt which might serve as impurities in the cullet. Then, dried the cullet and ground and ball are milled for several hours to make it finer and ready for sieving.

Making of test tiles

On the surface of tiles, small test tiles (green ware) were made for the purpose of testing glaze behaviors. Before it was placed in kiln, it should be allow to dry. The spy hole was left opened for an hour so as to allow the moisture to escape.

Glaze composition in biaxial blend

Glaze are formed from wasted borosilicate glass which already contain required silica and flux needed in formulating a glaze, biaxial blend of glaze composition that was adopted to determine the best ratio at which cullet will combine with other material to form a glaze.

During composition, following factors were strictly adhere:

- By using three beam balance, cullet was accurately measured
- With water been added, cullet was mixed with the combining materials and sired very well for thorough mixing.
- To avoid mix up of any kind, when every composed blend was labelled.
- For proper accuracy, also labelled the every produced test tiles after firin.

Recycling technique

Preliminary selected the recycling technique to apply CRT glass waste to promote recycling plan of CRT glass waste. Final techniques was elected by property on matter, consultation, visiting, self-review and evaluation of CRT glass waste.

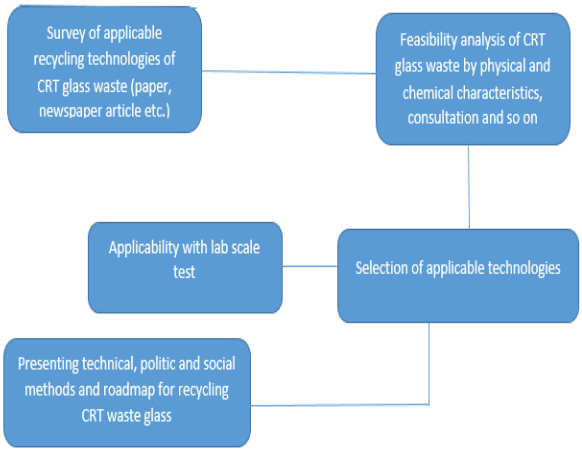

Figure: Overview on Recycling CRT glass waste

Characteristics of CRT glass waste

Main raw material and supplement raw material are separated by glass raw materials. Main raw material consists of alumina, magnesia, silica, boric acid, lime etc. that are the main component of glass but in supplement raw materials used of flux, oxidizing agent, emulsifying concentrate, flux, clarifying agent, reducing agent, coloring agent, decolorant etc. present in small quantity which are added to give special character to glass.

To compare the properties of CRT glass waste and other wasted glass in which CRT glass waste separate the funnel and panel, then differentiates below 200µm XRF (X-Ray Fluorescence) analysis was performed. Low melting catalyst component like K2O, Na2O is panel of CRT glass waste unlike to the bottle, glass, plate glass and it also contained 10% BaO component (for basic refraction of the optical glass). Funnel has some features because it 20% PbO that were excellent for index of refraction, dispersability and cutting but it is indispensable to be separated from panel since it has risk of leaching during recycling.

Technologies selection for CRT glass waste recycling

Using existing technologies, waste glass can be recycled that is light forming ceramic, clay bricks, glass wool, glazing, cement bricks, road filler, glass beads, sheet glass, lead smelting, container glass etc. The recycling technologies that of artificial marble, tile, glass beads CRT tube depend heavily on imports. In order to recycling CRT glass waste export because of assumption is established so hardly apply to waste CRT glass. For container glass, sheet glass, CRT glass waste was used as secondary raw materials that changes properties of produced glass will decline value of new glass. It is difficult to apply in case of road filler because of CRT glass waste recycling law does not exist.

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

This type of glass was evaluated by making cement block and clay bricks but using only panel because CRT's funnel has the potential of generating lead lechate. Method of making clay bricks was raw material mixing, molding, compression, drying and firing. Clay and CRT glass used particle size that is under 200µm. Using drying temperature was about 100℃ for at least 15 days and firing temperature is about 1,000℃ for at least 24 hours for preventing clay bricks crack. Making cement bricks method was raw material mixing, molding, curing, compression and drying. For stone powder and sand replaced CRT glass, CRT glass particle size was used that is 1-4mm, curing and drying temperature was about 20℃ during 15 days.

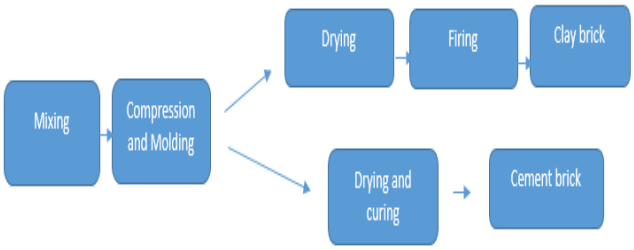

Figure: Manufacturing process of cement and clay brick

When CRT glass waste was applied, then contain most important factor was grain size classification. Cement brick, lead smelting, glass wool are size of some centimeter and clay brick was size some millimeter. Glaze was controlled to some micrometer, so was applicable to the CRT glass waste of existing process. From recycling center, CRT waste glass was released to separate panel and funnel. The CRT glass waste useful rate to contrast the existing raw material of each recycling technique.

Review of Literature

BHATTACHARYYA, DAS and MITRA 2005, concluded that standard 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 confirmed the presence of quartz and mullite. Due to the excess glass formation, quartz content decreased with increase of TiO2 content and its

simultaneous dissolution while mullite content increased with TiO2 content.

Bragança et.al 2006, concluded that produce whiteware bodies with formulations containing white-firing clay, glass waste and foundry sand. The quality of pressed ceramic bodies was good for the production of earthenware, faience and porcelain. Higher amounts of glass waste led to lower water absorption (WA), when compared with ceramic bodies prepared from porcelain formulation (FP) fired at 1200°C, making it possible to meet the technical specifications of porcelain. In density, there was no significance variation of formulations with foundry sand content that can be as high as 45% in the triaxial ceramic mass. For firing temperature that is between 1200 and 1250°C, higher densification after firing was achieved and the amount of added flux was more important than variation in foundry sand content.

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 waste can be used in raw stoneware glazes and it can be used in various body compositions and glaze compositions with high alkaline content by using advantages in color effects to create works with an artistic sense.

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 coefficients of thermal expansion of body and glaze and 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 evolution of microstructure and crystalline kinetics, influence of glass waste that is investigated in zircon based glass-ceramic glaze. It contain the role of glass waste which have three different percentages of tube light and borosilicate glass waste are selected and added as one of ingredients in composition of standard opaque glaze. XRD patterns show the presence of zircon crystal as the main crystalline phase along with the minor crystalline phases such as wollastonite and diopside. By scanning electron microscope (SEM), it can be understood from microstructural structural analysis that contain quite number of pores on glazed surface and average size of zircon crystal is reduced from 960 to 440nm. Due to increase in viscosity of glassy melt, reduction in crystal size that is achieved.

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 can be made from cullet with addition of any other fluxes. At low temperature, forming of non-crazing and non-crawling or running glazes from cullet. Borosilicate glass produced essential result when used as a source of silica/flux as compared with other resources which have the centered on use of soda-lime silica glasses in forming ceramic glazes. With KS standard, cement brick and clay brick lab-scale test both sample are satisfied. At existing technology, CRT glass waste apply recycling, panel and funnel are needed to separate clearly.

References:

Bragança, Saulo R., et al. "Recycling of Iron Foundry Sand and Glass Waste as Raw Material for Production of Whiteware." *Waste Management & Research*, vol. 24, no. 1, 2006, pp. 60–66., doi:10.1177/0734242x06061155.

Caki, Munevver, et al. "The Use of Glass Waste in Stoneware Glazes." *CeramicsTECHNICAL*, Nov. 2013, pp. 14–19.

Fadaly, Ezzat A. El, and Said A. El- Enany. "Lead Free Ceramic Cooking Ware from Egyptian Raw Materials." *International Journal of Current Microbiology and Applied Science*, vol. 4, no. 4, 2015, pp. 474–487.

I, Toluwalope O Oluwatuase. "The Use of Waste Borosilicate Glasses for Formulating a Functional Transparent Glaze." *International Journal of Advancements in Technology*, vol. 06, no. 01, 2015, doi:10.4172/0976-4860.1000141.

Incorporating ceramic manufacturing waste and recycled glass into the integral ceramic process. Available at: http://www.qualicer.org/recopilatorio/ponencias/pdfs/2012064.pdf

Seo, Yong-Chil, et al. "A Study on Recycling of CRT Glass Waste." *International Conference on Environment and Industrial Innovation*, vol. 12, 2011, pp. 237–241.

Spinner, Sam, and Albert Napolitano. "Further Studies in the Annealing of a Borosilicate Glass." *JOURNAL OF RESEARCH of the Notiona l Bureau Af Standards - A. Physics and Chemistry*, vol. 70A, no. 2, 1966, pp. 147–152.

Youssef, N.f., et al. "Utilization of Soda Glass (Cullet) in the Manufacture of Wall and Floor Tiles." *Journal of the European Ceramic Society*, vol. 18, no. 12, 1998, pp. 1721–1727., doi:10.1016/s0955-2219(98)00089-2.