

## **The Paper Ash - Cullet – Kaolin Clay: A Promising New Glass Ceramics**

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**Abstract:** The Abundance of solid waste in Malaysia including paper ash and cullet has a significant effect especially in the view of environmental management as well as in economical aspect. The reproduction of this waste into a priceless new ceramic material is therefore very imperative. Novel lightweight ceramics from waste material made of paper ash–cullet–kaolin clay can be successfully synthesized using a conventional solid-state reaction technique at a certain sintering temperature around 900 °C - 1100 °C. The justification on why these materials can be an alternative source for new promising glass ceramics applicable for many applications is reported.

**Keywords:** Paper ash, Cullet, Kaolin, Ceramics.

Rapid urbanisation and population growth in the past few decades have led enormous expansion of solid waste produced in Malaysia. It is estimated that in 2016 Malaysian generates 25,000 metric tonnes of domestic waste per day and forecast to escalate 2% per year. Among of the domestic waste, 45% are organic waste, 24% are plastics and followed by glass 18%, paper 7% and metal 6%. There is intention in a few years to recycle 20% of the total wastes generated while 15% for intermediate processing like incineration, gasification or Anaerobic digestion and finally 60% deposited into landfill. Unfortunately, implementation of waste management is still poor when only 5% of the total wastes generated are recycling while the vast wastes are disposed into landfill. Thus in order to pursue the recycle implementation and generate economy for Malaysian community glass ceramic industry is one of the compatible industries that can be applied to promote conservation of solid waste because it comprises a variety of compounds and could be prepared through diverse method[1–6]. Glass ceramic materials are known as polycrystalline solids containing residual glass phase, prepared by melting glass and forming by controlled crystallization. The model of controlled crystallisation of glass is subjected when suitable heat treatment is applied to glassy parent phase to form tiny crystals which the number of crystals, growth rate and their final size are controlled [7]. There are several techniques can be used to form glass ceramic materials which classically heat treatment of parent glass, peturgic method where very slow controlled cooling of a molten glass, without a hold at an intermediate temperature. Then, direct sintering of powder glass which advantageous for savings energy and cost required for consumption of glass ceramic [4, 8]. Glass ceramics from waste have extensively studied by direct sintering where the glass or waste is pulverised into powder, compacted and then subjected to required temperatures. Glass ceramic from waste materials has been used in many applications such as membranes in combustion technology, thermal and electrical insulation, electromagnetic radiation absorber and catalyst support for liquid metal or gas filtration [9–12].

Throughout the few decades, most largely waste-derived material used in the glass ceramic is soda -lime-silica scrap glass, SLS glass which commonly known as non- hazardous waste coming from packaging applications or flat glass. SLS glass have gained so much interest over ceramic industry due to high content of silicate component which can reduce natural source of silica, offers energy saving due to decrease of sintering temperature (low than melting stage 1350-1400°C), decrease emissions of carbon dioxide when replace Portland cement in cement industry also possible as filler material in stones or ceramics [13, 14]. The addition of SLS glass also may increase crystallization and viscosity of liquid phase at lower temperature, balance densification and crystallization, offer superior mechanical properties of glass-ceramics stoneware and also maintain the chemical inertia of toxic ions [15, 16]. Additionally, various industrial combustion ashes such as fly ash and glass cullet have extensively considered for ceramic or glass ceramic materials application [17]. Combustion ash have diverse useful elements and compounds which generally contains elements like Ca, Al, Cu, Pb, Cd, Ag, Mo, Fe, Ti, Na, Zn, and Cl in different concentrations depending variety of waste combusted. This elements has potential to create insulating, semiconducting or dielectric materials [18]. Subsequently, the ash from the paper industry can generate a high proportion of oxides that typically contain lime (CaO), silica (SiO<sub>2</sub>), and alumina (Al<sub>2</sub>O<sub>3</sub>). The combustion temperature of paper determines the mineralogical composition of the paper ash. Therefore, with the selection of a suitable temperature, the mineralogical content of paper ash can be tailored in accordance with industrial needs [19]. Some studies have been claimed that by optimization of compositional uniformity, particle size grading and heating rate of waste glass, fly ash powders and lime would practically utilized of waste materials into wollastonite glass-ceramics [20]. It was suggested that when sand in the glass and lime are replaced by wollastonite, the power consumption in firing temperature is reduced by 50 to 80°C and quality of the sample is improved [21].

Wollastonite has extensively attracted in the ceramic and glass-ceramic manufacturing. It has good physic-mechanical parameter, good dielectric properties, high resistivity and consequently can be used as high frequency electronic equipment. Predominantly, wollastonite are synthesized by solid state reaction with required high temperature (over 1200°C) and long time production. The appropriate mixing and molar ratio between CaO and SiO<sub>2</sub> from egg shell and silica has reported successfully synthesis wollastonite with low heating rate [21–24]. Thus, it was expected by using waste material like SLS cullet glass, paper ash it would efficiently reduce heating technique for solid state synthesis.

Thus, in order to improve the attractiveness of wastes derived materials from cullet and paper ash the structural and electrical properties can be considered. The mixture of cullet with incinerate paper ash is very promising since they are composed of ceramic raw materials such as SiO<sub>2</sub>, CaO, Al<sub>2</sub>O<sub>3</sub> and MgO [25]. Most of dielectric systems discussed in previous studies were using conventional raw materials. In the present work, paper ash cullet glass and kaolin clay has been used as a the natural resources. The method is usefully to reduce cost and nature of conservation. It is expected that these new glass ceramics, gives significant contribution to electrical, electroceramics, radio engineering or micro-electro mechanical system (MEMS).

The industrial wastes have been explored as the raw materials in the ceramic or glass-ceramic materials [16]. Many researchers have focussed on the synthesis of Wollastonite from bio waste . However, there are only a few reports on synthesize wollastonite from solid-waste to electronic base ceramic. It is suggested that, synthesize of wollastonite glass ceramic from solid waste and combustion waste such as paper ash, cullet glass and Koalin clay are benefits for

market exploitation and recycling of waste chemically inert ceramic. Thus, the investigation on the properties of ceramics based on cullet-paper ash-kaolin clay with different composition and temperature will be proposed.

Recently, ceramic packaging and multilayer substrate from ceramic have received increasing demand for circuit miniaturization and high performance device [26]. The used of Wollastonite glass ceramic possessed sufficiently high parameters of mechanical and good in dielectric properties and consequently can fulfil the demand of ceramic substrate. The dielectric properties of ceramic are affected by bonding mechanism like ionic or covalent bond and crystallinity in the materials. It is reported that Wollastonite exhibit unique dielectric properties such as low dielectric loss due the effect of ionic exchange between  $\text{Si}^{2+}$  and  $\text{Ca}^{2+}$  ions [26]. The understanding of the dielectric properties of these materials has not yet emerged. Therefore, the study of crystal structural and dielectric properties such as changes of porosity, permittivity and dissipation factor ac with varied sintering temperatures of wollastonite are important to understand the source of these excellence [26–29]. It is expected that this study would give information on the basic knowledge between structural and dielectrical properties of glass-ceramic from this waste.

In conclusion, it is worth and vital to study the ceramic from waste such as cullet, paper ash and kaolin clay using a modified solid stated reaction. A new kind of glass ceramic with better properties are expected to be derive from this mixture.

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