

Sustainable Cullet-Clay Glass Ceramics Containing Titanium Nitrate

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Abstract: The search for sustainable glass is still a major issue. Using the definition of sustainable, it is always possible to compose a sustainable glass ceramics using cullet or glass waste as the main glass host. Other variation of composition might be use to tailor the requirement of the glass ceramic production for their respective purposes. In this paper, ceramics containing titanium nitrate and clay will be prepared by using cullet as a glass host. Their properties are characterized in term of phase existence and the surface morphology of the samples.

Sustainability is a broad term is used to describe the myriad ways in which a product or process can impact the environment, society and economy [1]. Glass is a sustainable, fully recyclable material which provides great environmental benefits such as contributing to mitigating climate change and saving precious natural resources. It is also highly appreciated in many applications for its inert nature and its contributions to safeguarding people's health and well-being.[2]. The composition of a package is another way to measure its sustainability, and glass is made from three abundant and natural ingredients: sand, limestone and soda ash. When glass breaks down, it remains safe and stable, and releases no harmful chemicals into the soil. So even when glass isn't recycled, it does minimal harm to the environment.[3]. There are at least five reasons why glass will be the next sustainable friend1. Firstly, it's endlessly recyclable, which means that recycled glass is always part of the recipe for glass [4]. Secondly, glass has the best barrier protection compare to. any alternative packaging materials.[5]. It is also reported that the more recycled glass used, the less energy is wasted to create new glass [6]. This is the perfect reason on why glass is a sustainable material since using cullet means that only small amount of energy is wasted. Another reason that worth to mention is that glass can reflect and absorb solar energy [7]. In this case, at any glassy surface, the conservation energy will always take place. Lastly, it is reported that for every ton of recycled glass used, it will save of about 670 kg of CO₂ [8]. This of course is very important way to balance the existence of gaseous in the environment.

To making the cullet glass bottles, container and jar are collected and are taken to a bottle depot or glass Recycling plant. Then the magnet conveyor is used to removes ferrous material like lids and caps [9]. The spinning drum is then used to dries the glass before being crush into a smaller pieces called cullet using a crusher feed.

Many countries in the worlds use recycle glass beads in the road paint for reflective quality [10] while the use for countertops are becoming popular everywhere [11]. In some golf clubs, this fine glass sand is used as aids in a bunker stability by forming an abrasive dry layer on the land surfaces thereby creating condition that can deter earthworms [11]. Inter-particles friction is relatively high making glass sand less susceptible to particle inter-packing and compaction than rounded natural sands. It also improves drainage [12]. Other uses would include electrical insulators, bioactive glass, smart glass, glass for buildings and glass ceramics.

Fig. 1 shows the diagram for the preparation of glass ceramics. Meanwhile, Table 2 shows the ceramic composition and appearance of the sample.

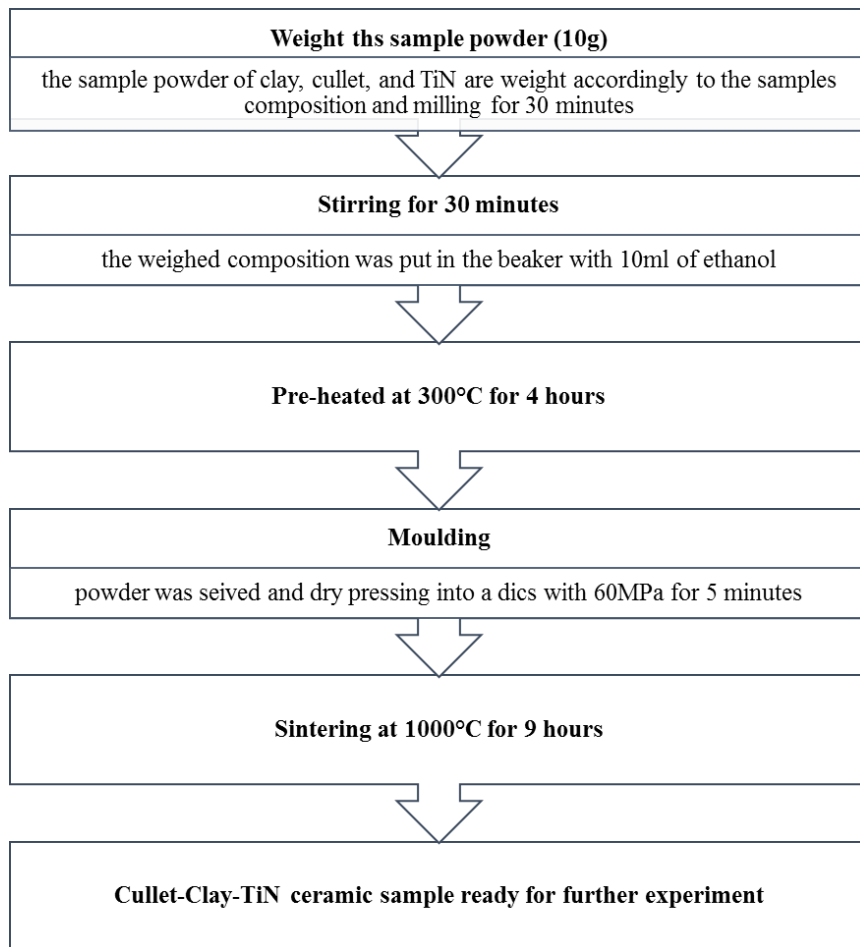


Figure 1: The preparation process of glass ceramics

Table 1: Ceramic composition and visual appearance

Sample No	Composition (wt%)			Visual Appearance
	Cullet	Kaolin	TiN	
S1	60	40	-	Soft surface, white
S2	59	40	1	Soft surface, white
S3	58	40	2	Soft surface, white
S4	57	40	3	Hard surface, white
S5	56	40	4	Glazing and hard surface, yellowish
S6	55	40	5	Glazing and hard surface, yellowish
S7	54	40	6	Glazing and hard surface, yellowish

During sample preparation, the sample has to be pre-sintered to get rid-off all the water content and impurities. The changes of colour and surface texture is observed during the preparation. Colour changes is perhaps due to changes in valence no of Ti from +3 to +4. Meanwhile, harder surface might be due to addition of more TiN. Fig. 2 shows the sample of glass ceramics containing TiN. From Fig. 2, the changes in colour can clearly be observed.

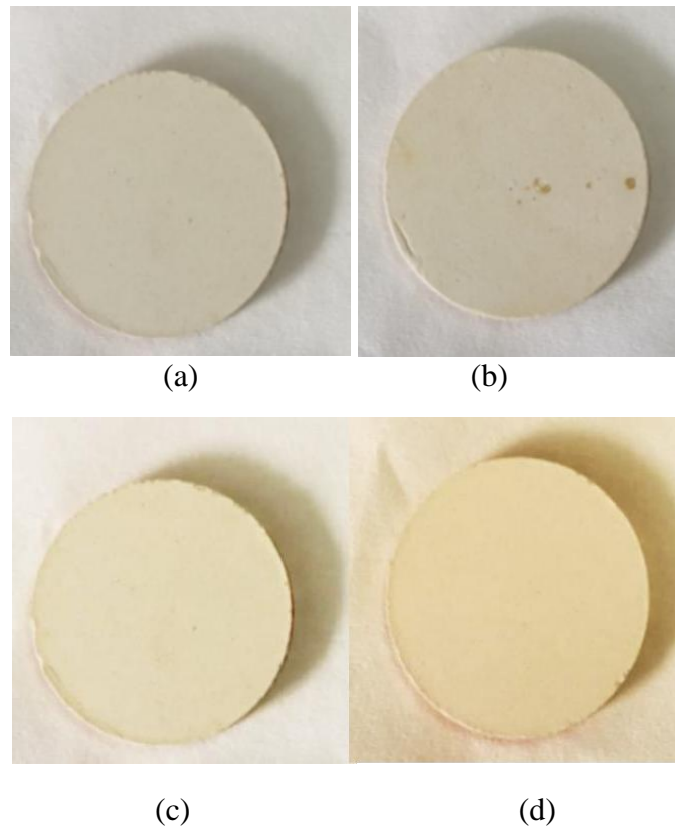


Figure 2: Shows sample (a) S1 (b) S3 (c) S5 and (d) S7

Fig. 3 shows the XRD pattern of ceramic as sintered at 1000°C at various cullet level. From Fig. 3, the phase occurrence of the ceramic can be figure out as q-quartz, t-tridymite, a-TiO and d- Al₂O₃

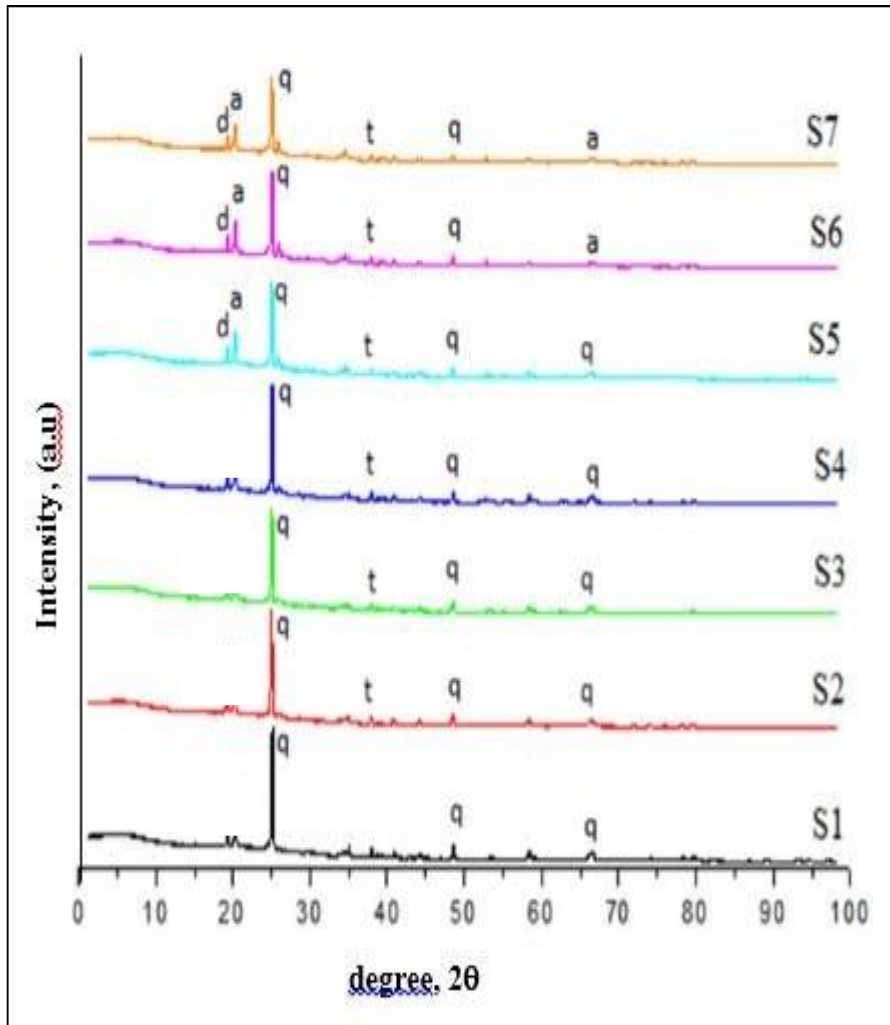
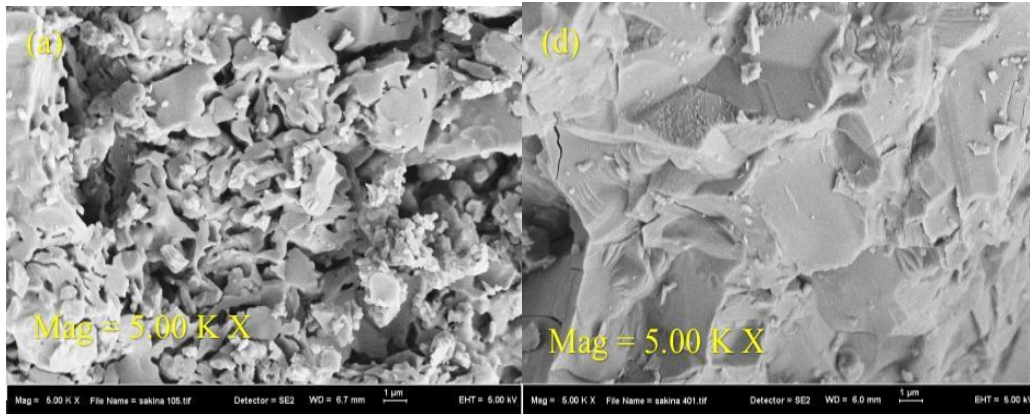


Figure 3: The XRD pattern and the phase occurrence of the ceramics samples.

According to Fig. 3, the major phases are quartz and tridymite while as the TiN is further added, a minor phase of alumina, Al_2O_3 start to emerge. The phase of TiN has not been observed and this might be due to the small concentration of TiN.

Fig. 4 shows the surface morphology of the samples under the magnification of SEM. From this figure, it can be seen that for S1, the surface is irregular with lots of pores. In contrast, for S7, there is only a minimum amount of pores can be seen. Most of the surface is flat and hardened. This indicate that the addition of more TiN, may flattened and hardened the surface of the ceramics.



(a)

(b)

Figure 4: The surface morphology of the cullet-clay-TiN glass ceramic samples for (a) S1 and (b) S7

Conclusion: A sustainable glass ceramics of Cullet-Clay containing titanium nitrate can easily be formed. XRD results shows the occurrence of quartz and tridymite as major phase while Al_2O_3 as minor phases. Ceramic containing more titanium nitrate exhibits flattened and hardened ceramics surface.

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