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Insights into reaction mechanism of Na_2CO_3 in foaming process of cullet powder

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Soda (Na_2CO_3) is one of the major raw materials for producing most of the daily used glasses. It often acts as effective fluxing agent in glass melting and foaming agent for producing lightweight glass materials due to its release of CO_2 at elevated temperatures. When Na_2CO_3 is added to a batch prior to glass melting, the resulting decomposition product Na_2O has strong impact on the melt viscosity, phase separation and crystallisation behaviour, and also mechanical properties of the final glass. This is relatively well understood in literature. In contrast, when Na_2CO_3 is added as a foaming agent together with glass cullet powder, the impact of the resulting Na_2O on the glass structure at the foaming temperatures has not been well understood. Here, we show that Na_2O can be readily incorporated into the network structure of the glass phase at temperatures much lower than normal batch melting temperatures. This is verified by a sharp decrease of the glass transition temperature (T_g) of the resulting foam glass when the foaming temperature is increased from 650 to 800 °C for various contents of Na_2CO_3 (up to 22 wt%). Upon further raising the foaming temperature, T_g reaches a plateau for lower Na_2CO_3 content, whereas it slightly increases again for the higher Na_2CO_3 due to possible crystallization. The sharp decrease in T_g implies that Na_2CO_3 reacts readily with the cullet powder at rather low temperatures. The released CO_2 at an optimum temperature causes ideal foaming effect in the glass, making the studied cullet powder potentially suitable for producing insulation materials. Finally, we discuss these results based on supplementary x-ray diffraction and scanning electron microscopy analyses.