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Revealing chemical reaction during glass foaming using evolved gas analysis

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Carbon-containing foaming agents are industrially important for the production of foam glass. For an efficient foaming process the supply of oxygen has to be controlled. Before reaching the sintering temperature the presence of oxygen in the surrounding atmosphere has to be limited to protect the carbon species from premature oxidation.[1)] Once the carbon is fixed in the softened glass, the oxygen needed for its oxidation is supplied by multivalent ions present in the glass.[2)] The multivalent ions diffuse to carbon, where the oxidation reaction, i.e. foaming reaction, takes place. Thus it is important that at the foaming temperature a suitable amount of oxygen is available in the glass melt.

To increase the amount of oxygen available for oxidizing the carbon, multivalent ions can be added to the glass by re-melting virgin glass or by adding directly to the powder mixture. It is important that the multivalent species are in appropriate redox state to be able to supply oxygen at the foaming temperature.[3)] Manganese is a multivalent element and its higher valence state ion can be used as an oxidizing agent to supply the oxygen needed for carbon oxidation. It is frequently added to the foaming powder mixture in the form of MnO_2. Due to its thermal instability it can be used as a sole foaming agent. However, the actual oxidation state of the manganese involved in the foaming reaction has not been considered. Here we report the foaming mechanisms when using carbon and/or manganese oxides as foaming agents in oxygen-containing and oxygen-free atmosphere. The results reveal that the manganese compounds involved in the foaming reactions are Mn_2O_3 and Mn_3O_4 depending on the oxygen partial pressure, presence of carbon and foaming temperature, while the oxygen released by thermal decomposition of MnO_2 is in great part lost to the atmosphere.

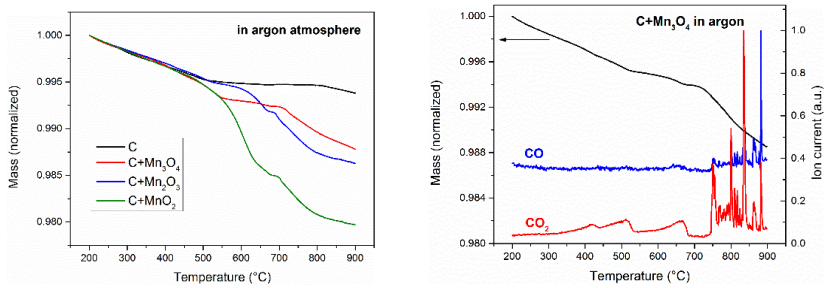

Figure 1: (a) DTA analysis of different foaming agents. (b) DTA-MS analysis

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