Redox in glasses: interactions with radiation

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Abstract

Redox processes can exert significant influences on the processing and properties of glasses, both during production and in-service. For example, control of oxygen partial pressures during glass melting and cooling control the oxidation state of multivalent species therein, influencing foaming (or its avoidance), refining, optical properties such as absorption and fluorescence, chemical durability and crystallization behaviour. However, a less-researched aspect of glass redox is in the interaction of multivalent species in glasses with radiation. This can manifest through interactions with high-energy radiation including UV, which causes solarisation (see, for example, [1]), and even higher energies such as X-rays and γ-rays [2] which can lead to colour centres, point defects and modifications of glass structure or properties. Here we will illustrate, with examples from our recent research, and from other research (see, for example, [3]), interactions of multivalent species in silicate and borosilicate glasses of relevance to technical and radioactive waste glasses, with UV and γ-rays. We will show that, by using selected multivalent transition metal dopants, the optical absorption and fluorescence behaviour of glasses can, to an extent, be tailored or controlled; and the effects of high-energy radiation upon the redox, structure and properties of oxide glasses can be managed or, in some cases, mitigated.

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