deleterious effects on all cellular components. ROS inhibit osteoblast differentiation and mineralization and induce necrosis, enhance osteoclasts activity with consequent bone resorption, cause partial degradation of fibronectin, and increase the expression of proinflammatory cytokines. All these effects highlight an association between oxidative stress, bone mass, and consequently osteoporosis (Abdollahi et al., 2005). In physiological conditions, there is a balance between ROS production and cellular antioxidant defense mechanisms, mainly based on enzymatic routes (superoxide dismutase—SOD, catalase, glutathione peroxidase—GPx) and nonenzymatic ones (phenolic compounds, vitamin C, vitamin E, and glutathione) (Rosenfeldt et al., 2013). Trauma, bacteria invasion, hypoxia, tissue injury, and surgical intervention are associated with an increase in ROS production accompanied by a reduction of the antioxidant capabilities of the organism, resulting in a higher risk of oxidative stress (Rosenfeldt et al., 2013). In this context, the antioxidant properties of biomaterials intended for bone contact applications are significant.

Despite the wide research and application of antioxidant materials in various fields (cosmetics, foods, nutraceuticals, pharmacology, etc.), the antioxidant/pro-oxidant behavior of biomaterials and especially of bioactive glasses has attracted only limited attention. A thorough investigation into the effects of bioactive glasses and their dissolution products on the production/balance of ROS is a challenging approach to widen the potential of these biomaterials.

The antioxidant behavior of bioactive glasses can be associated with glass surface reactivity and functionalization, such as the presence/release of specific ions (e.g., Ce, Sr) or coupling with antioxidant materials. Some examples are reported in the following paragraphs.

Ionic composition of bioactive glasses is the basis of their reactivity and biological behavior. The introduction of specific ions such as fluoride and copper can have an impact on their oxidative potential. In particular, it has been reported that the addition of F (5–15 mol%) increases lipid peroxidation and ROS production in MG-63 osteoblast cells, and inhibits the pentose phosphate pathway, the glucose 6-phosphate dehydrogenase activity, and the glutathione activity as signs of oxidative stress of the cells (Bergandi et al., 2010). Similarly, the introduction of Cu into 45S5 Bioglass (1–2.5 w/w%) increases the ROS production in human osteosarcoma cells (HOS) (Milkovic et al., 2014).

Cerium oxide nanoparticles have been widely studied for their antioxidant enzyme-mimetic activity and radical scavenging ability (Nelson et al., 2016). The main mechanism on the basis of these properties seems to be the redox couple (Ce^{3+}/Ce^{4+}) on the material surface. Cerium has been introduced in silica-based bioactive glasses (starting from 45S5 Bioglass composition) in order to have Ce^{3+}/Ce^{4+} in the bulk and surface of the glasses. As both Ce^{3+} and Ce^{4+} ions are necessary for the reaction with hydrogen peroxide H_2O_2, appropriate Ce^{3+}/Ce^{4+} ratio makes the glass able to degrade H_2O_2, mimicking the physiological action of catalase (Nicolini et al., 2015; Pedone et al., 2016). The antioxidant activity increases with cerium content and it has been found that a