

3.2.5 Development of a Doped Macroporous Bioactive Glass

Implants are often made from massive glass, inducing a slow bone substitution due to relatively reduced and incomplete degradation. In order to optimize bone tissue regeneration, it would be advantageous for these implants to be porous. The first advantage of this type of material is its porosity, which favors osteoconduction (i.e., the ability of the material to allow adhesion, the migration of cells within it, the development of a vascular network, and the deposition of new bone tissue in direct contact with the material without any fibrous interposition). Indeed, the bone could develop within this material and would gradually take its place. The second advantage is the chemical reactivity of bioactive glass, which is significantly superior to that of conventional bioceramics (calcium phosphate, hydroxyapatite). This reactivity would thus reduce the attachment time of the implant in the host medium.

The synthesis of a macroporous bioactive glass was carried out with the glass P3C2 of the molar composition: 43.65% SiO₂-22.80% CaO-30.55% Na₂O-3% P₂O₅. The glass was chosen for its good compromise between the results of in vitro bioactivity and its easy production in large quantities. Macroporous bioactive glass was obtained by transposing a process developed in the laboratory for the production of synthetic bone substitutes from ceramic powders (Descamps et al., 2008). It involves 5 stages:

- (1) A glass grinding procedure was developed to obtain a micrometric glass powder. The grinding was carried out exclusively with anhydrous ethanol as a solvent using an agate milling jar and balls to avoid pollution. A glass powder with an average particle size of around 2.5 μm after 9 h of planetary grinding was obtained.
- (2) The polymeric frame is prepared starting from polymethylmethacrylate balls (PMMA). The balls are placed in a metallic mold with a solvent, and a “chemical forming process” makes it possible to weld them all together. This technique allows any desired form to be obtained. A study was carried out, allowing correlating the withdrawal with the diameter of bridging between the balls of PMMA. Thus, for this study, the withdrawal was fixed at 400 μm, which makes it possible to obtain a diameter of interconnected 130 μm, starting from balls of PMMA of diameter ranging between 500 and 600 μm. This PMMA skeleton corresponds to the negative of the macroporous structure, which was carried out starting from the glass powder.
- (3) Then, a glass powder suspension was elaborated in anhydrous ethanol, with a glass powder ratio of 70 wt% and a phosphoric ester ratio of 0.08 wt%, which ensures slurry defloculation. The slurry must be both sufficient to properly impregnate the organic building in balls of PMMA, and have a sufficiently large amount of dry matter to obtain good densification of material. The dispersion is carried out in a planetary mixer for 30 min at 150 turns/min.
- (4) The PMMA skeleton was soaked in the slurry in a plaster mold, which absorbs the solvent.