4.2.5 MBG Scaffolds

For repairing large bone defects, three-dimensional (3D) MBG porous scaffolds possess more advantages than MBG particles or coatings because 3D scaffolds with a highly interconnected macroporous network facilitate cell migration, bone in-growth, and nutrient delivery (Zhu et al., 2008; Wu et al., 2016). As compared with resorbable polymers and HA, MBGs are more promising materials as scaffolds for tissue engineering because of their excellent biocompatibility, bioactivity, osteoconductivity, and osteoinductivity.

The MBG scaffolds are widely fabricated by the EISA method using a combination of polyurethane sponge and block copolymer $EO_{20}PO_{70}EO_{20}$ (P123) as co-templates (Zhu et al., 2011b, 2008; Wu et al., 2016; Wei et al., 2014; Lin et al., 2015). Zhu et al. have reported that the incorporation of Ca and P into the MBG scaffolds facilitates the formation of the CHA layer on the surfaces (Zhu et al., 2008). The in vitro cell tests indicate that primary human bone-derived cells (HBDC) on the scaffolds of MBGS 80S15C (S and C represent SiO_2 and CaO; 80 and 15 are the molar ratios of SiO_2 and CaO in percentage × 100, respectively) present better cell adhesion than those on those of MBGS 70S25C, MBGS 90S5C, and MBGS 100S (Zhu et al., 2008). In addition, zirconium (Zr), magnesium (Mg), strontium (Sr), and europium (Eu) are important trace metallic elements, which play an important role in bone regeneration via stimulating osteoblastic cells (Zhu et al., 2011b, 2008; Wu et al., 2016; Wei et al., 2014). The ZrO_2-substituted MBG scaffolds enhance the mechanical strength, and exhibit a better biological property than other MBG scaffolds (Zhu et al., 2011b). Wu et al. have incorporated Eu into MBG scaffolds (Eu-MBG) to achieve bifunctional biomaterials with both the bone regeneration and biolabeling (Wu et al., 2016). The Eu-MBG scaffolds have highly interconnected pores of 300–500 μm, a high specific surface area of 140–290 m^2/g, and well-ordered mesopores of approximately 5 nm. The Eu, Si, Ca, and P elements are uniformly distributed on the MBG scaffolds (Wu et al., 2016). Besides polyurethane (PUF), stem core, sodium chloride (NaCl) particle, wool sponge, and Mediterranean sea sponge can be used as macroporous templates to prepare MBG porous scaffolds, and the interconnected macropores provide the potential for tissue growth and neovascularization (Lin et al., 2012b; Li et al., 2008b; Niu et al., 2015; Liu et al., 2013; Zhu and Kaskel, 2009).

For the fabrication of porous MBG scaffolds, traditional methods such as particle leaching, freeze-drying, and hard templating have some limitations in controlling macroporous structures and mechanical properties (Zhu et al., 2011b, 2008; Wu et al., 2016; Wei et al., 2014; Lin et al., 2015, 2012b; Li et al., 2008b; Niu et al., 2015). Recently, a 3D printing technique has been developed to control precisely the architectures of porous scaffolds via computer-assisted design (CAD)/computer-aided manufacturing (CAM) under mild conditions (Pei et al., 2016; Zhao et al., 2014, 2015; Zhang et al., 2015, 2014a; Wu et al., 2013).