The micro/nano-sized bioactive glasses and their cytological behaviours

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Statement of Purpose: Compared to traditional melting bioactive glass (BG), the sol-gel derived BG usually exhibits enhanced apatite-forming ability and biological properties due to their abundant micro/nano structures and large surface area, which may have better effect on bone tissue repair and regeneration [1,2]. Therefore, we designed and prepared several kinds of micro/nano sized sol-gel derived BG with different composition and morphology through the sol-gel process, co-precipitation method, organic template assembly and electrostatic spinning techniques. In addition, their physicochemical properties, apatite-forming ability and biocompatibility were also studied.

Methods: Nanoscale bioactive glasses (NBGs) particles were synthesized by an acid-catalyzed sol-gel method and gelation-induced phase separation technology using polyethylene glycol (PEG10000) as a phase separation agent. Mono-dispersed bioactive glass nanospheres (MBGNs) were prepared by the sol-gel process combining co-precipitation method using dodecylamine as catalyst. Radial and wrinkled bioactive glass nanospheres (RWBGNs) were synthesized by sol-gel process combining the micro-emulsion technique. The micro/nano scale bioactive glass fibers (MNBGFs) were prepared by electrostatic spinning method. Meanwhile, the in vitro apatite-forming ability and cellular behavior as well as the cell viability of the materials were investigated.

Results: The micro/nano sized BGs synthesized by different methods are show in Figure1. By adjusting the PEG/tetraethoxysiliane (TEOS) weight percent to 10%, 15% and 20%, the diameter distributions of NBGs are 2000-4000nm (Figure 1a, P10-NBGs), 400-800nm (Figure 1b, P15-NBGs) and 40-180nm (Figure 1c, P20-NBGs), respectively. MBGNs exhibit spherical shape and mono-dispersity (Figure1d) and the size of MBGNs can be controlled by changing the concentration of the precursor (TEOS) and the ratio of water and ethanol. RWBGNs show radial-fibrous structure with wrinkled surface and an average particle diameter of 180nm (Figure 1e), while the MNBGFs possess fibrous structure (Figure 1f) and their diameters can be easily tuned by altering the hydrolysis time, the molar ratio of water and TEOS etc. Furthermore, an apatite layer was observed on the surface of all kinds of micro/ nano sized BGs after soaking in simulated body fluid (SBF) for 7 days , indicating their excellent abilities to induce apatite formation and bond to bone tissue(Figure 2). And after 4 hours of culturing with human marrow mesenchymal stem cells (hMSCs), we found that the adhered and spreaded hMSCs could be seen on all the NBGs surfaces (Figure 3). The cell viability tested by MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay indicated that the NBGs are non-toxicity to the hMSCs cells, which demonstrated their good biocompatibility for bone related cells.

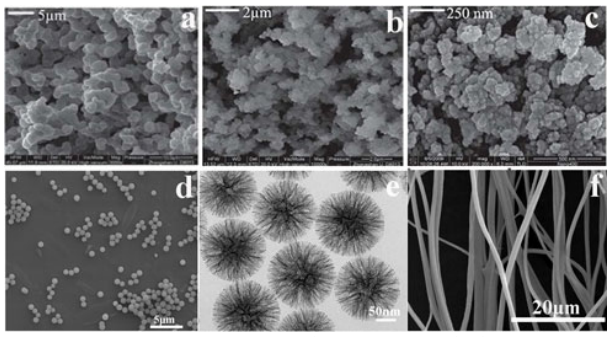

Figure 1. SEM images of different morphologies of micro/nano sized BGs

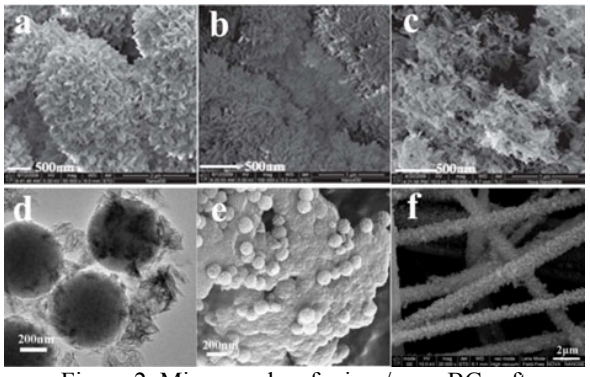

Figure 2. Micrographs of micro/nano BGs after immersion in SBF

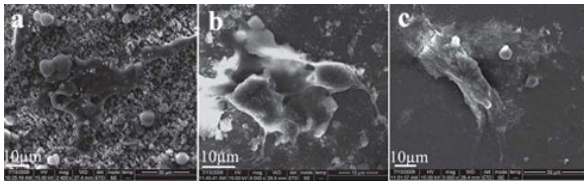

Figure 3. hMSCs adhesion morphology cultured on NBGs for 4 h. (a) P10-NBGs,(b) P15-NBGs,(c) P20-NBGs

Conclusions: Different morphologies and sizes of micro /nano sized BG have been successfully synthesized. These materials show great potentials for use in bone tissue repair and regeneration.

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