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316L纤维尺寸和含量对HA-ZrO_2(CaO)/316L纤维复合生物材料性能的影响

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摘要 研究了316L纤维的长度、直径与含量对HA-ZrO_2(CaO)/316L纤维生物复合材料的力学性能的影响规律. 结果表明: 纤维直径为40μm的复合材料力学性能优于纤维直径为50μm的复合材料; 纤维长度为0.8～1.2mm的复合材料力学性能优于纤维长度为2～3mm的复合材料; 随着纤维体积分数增大, 纤维之间相互接触而导致在复合材料中形成的微孔增多, 并成为微裂纹源, 导致材料力学性能下降. 含20vol%直径为40μm、长度为0.8～1.2mm的316L纤维的HA-ZrO_2(CaO)/316L纤维生物复合材料的综合力学性能最佳, 其抗弯强度、杨氏模量、断裂韧性和相对密度分别为140.1MPa、117.8GPa、5.81MPa·$m^{1/2}$和87.1%. 复合材料微观组织随HA粉末和316L纤维成分的变化呈规律性变化, 没有出现明显的裂纹或孔隙, 316L纤维与HA-ZrO_2(CaO)基体紧紧地咬合在一起, 其结合主要靠基体对316L纤维的物理附着力所致. 基体中发生微量Fe元素扩散, 但在316L纤维中不发生基体Ca、P元素的扩散. 含5%316L纤维复合材料表现为脆性断裂, 而含10%、20%、40%316L纤维复合材料均表现为韧性断裂, 且韧性程度随316L纤维含量的增加而增大.

关键词 316L不锈钢纤维(316L纤维) 复合生物材料 微观结构 力学性能 断裂性能

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Influence of 316L Fibre's Dimension and Content on the Properties of HA-ZrO_2(CaO)/316L Fibre Biocomposite

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Abstract The influence of 316L fibre's dimension and content on the properties of HA-ZrO_2(CaO)/316L biocomposites was studied. The results show that mechanical properties of the composites with fibre diameter of 40μm is better than that of 50μm, and with fibre length of 0.8--1.2mm is better than that of 2--3mm. Micropores increase with volume fraction of 316L fibre because of mutual contact among fibres, which becomes microflaws and leads to descending of mechanical properties. Therefore, it is concluded that HA-ZrO_2(CaO)/316L fibre biocomposite reinforced by 20vol% fibre with dimension of φ40μm×(0.8--1.2)mm has optimal mechanical properties, i. e. bending strength, Young's modulus, fracture toughness and relative density are 140.1MPa, 117.8GPa, 5.81 MPacdotm1/2 and 87.1%, respectively. No obvious flaws or pores appear in the composites and 316L fibre is enwrapped in the HA-ZrO_2(CaO) matrix and both integrate each other tightly. The combining mechanism of matrix to 316L fibre is physical adhering force. Small amount of Fe element of the toughing phase diffuses in the HA(ZrO_2) matrix, but no Ca, P element of the matrix diffuses in 316L fibre toughing phase. Both matrix and toughing phase are relatively independent and no chemical reaction is observed in the composites. Brittle fracture and tough fracture are illustrated in HA-ZrO_2(CaO)/316L fibre biomaterials with 5vol% fibres and 10vol%, 20vol%, 40vol% 316L fibres, respectively, and the toughness increases with the increasing of 316L fibre contents in HA-ZrO_2(CaO)/316L fibre biomaterials with 10vol%, 20vol%, 40vol% 316L fibres.

Key words 316L stainless steel fibre (316L fibre) biomaterials microstructure mechanical properties fracture properties

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