

## EXAMPLE 4

The components, i.e. liquid monomer, polymer containing the finely comminuted bioactive glass ceramic material and hardening or curing agent are placed, for instance, into a cylindrical mixing vessel and are thoroughly mixed with each other. Polymerization sets in and the viscosity of the mixture increases continuously. The glass ceramic material is isotropically distributed in the thoroughly blended mixture. On discontinuing further stirring and mixing, the glass ceramic particles start to settle due to the differences in specific gravity of the components. As a result of such settling the particles are concentrated at the bottom part of the mixing vessel. After exothermic hardening or curing of the mixture has been finished, there is obtained a cylindrically shaped body of organic composite material in which the bioactive component is anisotropically distributed in the direction of the axis of said body.

## EXAMPLE 5

Anisotropic distribution of the bioactive glass ceramic component in radial direction in the mixture of liquid monomer, polymer, hardening or curing agent, and glass ceramic particles is achieved by causing the cylindrical vessel containing said mixture to rotate around its axis. By utilizing the centrifugal power exerted thereby anisotropic distribution and drifting of the glass ceramic particles into the other zones of the cylindrical body takes place.

The material obtained according to Examples 4 and 5 can be used as replacement for bones, parts of bones, and teeth. The cylindrical mixing vessel may be shaped in the form of the bone or teeth replacement, so that the polymerized product can directly be used for said purpose. Or it can be shaped mechanically as mentioned hereinabove.

The bone cement obtained according to Examples 1 to 3 can be used, as described hereinabove, for firmly attaching either artificial implant material such as artificial teeth or natural bones and parts of bones to bones of the body. Such bone cement, in proper concentration can also be used as filler material to eliminate and cover local defects in bones.

As stated hereinabove, it may become necessary to cool the place of application of the bone cement or the mold for producing bone replacement material so as to control the strongly exothermal polymerization reaction. For this purpose the place of application can be rinsed, washed, or irrigated with biocompatible, non-aggressive, sterile cooling liquid. It is also possible to attach to the bone part which is in contact with the bone cement mixture according to the present invention, a cooling trap, for instance, a copper or other metal sleeve which is connected in a heat conductive manner with a cooling agent reservoir. The heat of polymerization is then conducted away from the place of application of the bone cement so that the required heat dissipation is achieved.

The term "bioactive material", as used herein and in the claims annexed hereto, indicates that the respective material is not only biocompatible, i.e. will not be rejected by the human or animal body, but also that it causes the body to attach thereto and grow thereon the specific tissue, bone material, or the like of the body itself.

Of course, many changes and variations in the polymerizable monomeric material, the prepolymerized

and/or polymer plastic material added to the preparation, in the hardening or curing agents and catalysts used, in the composition of the glass ceramic material and its particle size, in the manner of compounding and processing the components of the mixture, in their use as bone cement or as prosthetic material for humans and animals, and the like may be made by those skilled in the art in accordance with the principles set forth herein and in the claims annexed hereto.

We claim:

1. A composite material for prosthetic purposes, said material consisting of a polymerizable plastic matrix and between about 10 and about 70% by volume of inorganic bioactive and biocompatible material.

2. The composite material of claim 1, in which the bioactive material is a bioactive glass ceramic material having an apatite crystal phase and being of the following composition, in weight percent:

- 20 between about 20.0% and about 60.0% of silicon dioxide  $\text{SiO}_2$ ,
- between about 5.0% and about 40.0% of phosphorus pentoxide  $\text{P}_2\text{O}_5$ ,
- 25 between about 2.7% and about 20.0% of sodium oxide  $\text{Na}_2\text{O}$ ,
- between about 0.4% and about 20.0% of potassium oxide  $\text{K}_2\text{O}$ ,
- between about 2.0% and about 30.0% of magnesium oxide  $\text{MgO}$ , and
- 30 between about 5.0% and about 40.0% of calcium oxide  $\text{CaO}$ .

3. The composite material of claim 2, additionally containing between about 0.005% and about 3.0% of fluoroine  $\text{F}_2$ .

4. The composite material of claim 1, in which the bioactive material is incorporated homogeneously in the plastic matrix so as to achieve isotropic particle distribution in said plastic matrix.

5. The composite material of claim 1, in which the bioactive material is of a particle size between about 90  $\mu\text{m}$ . and 250  $\mu\text{m}$ .

6. The composite material of claim 2, in which the bioactive material is of a particle size between about 90  $\mu\text{m}$ . and about 250  $\mu\text{m}$ .

7. The composite material of claim 3, in which the bioactive material is of a particle size between about 90  $\mu\text{m}$ . and about 250  $\mu\text{m}$ .

8. The composite material of claim 1, in which the bioactive material is incorporated non-homogeneously in the plastic matrix so as to achieve anisotropic particle distribution in said plastic matrix.

9. The composite material of claim 1, said composite material having admixed thereto at least one reinforcing component consisting of a fiber material so as to improve its mechanical strength properties.

10. The composite material of claim 9, in which the reinforcing component consists of glass fibers.

11. The composite material of claim 1, in which the polymerizable plastic matrix is a methacrylate matrix.

12. In a process of producing the composite material of claim 1, the steps comprising

- a) adding a hardening agent to a fluid monomeric plastic material, and
- b) mixing thereto the finely comminuted bioactive glass ceramic material.

13. The process of claim 12, in which the fluid monomeric plastic material is a methacrylate plastic and the