SOME PHYSICAL PROPERTIES OF POLYMETHYLMETHACRYLATE DENTURE RESIN MIXED WITH METAL POWDERS

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ABSTRACT

The effect of mixing copper and aluminium powder, with different volume fractions ranging from 0 to 10 %, with polymethylmethacrylate denture resin is studied. The thermal conductivity and the Charpy impact value showed reasonably increase with increasing the volume fraction of the metal powder. The compressive strength showed also an increase with increasing the volume fraction of the metal powder but the increase was not significant.

INTRODUCTION

The polymethylmethacrylate (PMMA) is a sort of polymers and is used as a denture base resin. It is important to improve its low thermal conductivity for better appreciation of taste as well as reducing the foreign body feeling of dentures [1]. Recently studies were made to improve the physical properties of (PMMA) by adding metals to it in different forms [2-4].

In this work, the effect of adding copper and aluminium in the form of fine powders to(PMMA) on the thermal conductivity, compressive strength and impact energy was investigated.

EXPERIMENTAL

Copper and aluminium in a powder form, with purity 99.9 % from Koch-Light Laboratories Ltd England with a particle diameter of about 15 μm, were individually mixed in different ratios by weight with polymethylemethacrylate (PMMA) (Resin for dentures, superacryl, SPOFA-DENTAL, PRAHA). The percentage volume fraction of the metal phase was then calculated by the use of the predetermined densities of the metal phase and the PMMA resin. The samples were polymerized by the constant temperature method [5] in special molds. For thermal conductivity measurements, the samples were made in the form of disks of 25 mm diameter and about 2 mm thickness. For compressive strength measurements, the samples were made in the form of cubes of 10 mm side length. For the impact test, they were made in the form of bars with a square cross-section 10x10 mm and length 75 mm. The bars were notched in the middle with angle 45° and depth 2 mm.

The thermal conductivity was measured for each sample by a steady state method using an apparatus whose description and theory can be found in a previous work [6].

The compressive strength was determined by a universal testing machine and the impact energy was determined by the Charpy method using an impact testing machine.

RESULTS AND DISCUSSION

The experimental results of the thermal conductivity were compared with some theoretical models for two phase systems [7-9] but the most convenient model was that of Russell [7] which states that:

$$K_E = K_p\left[\frac{1-\phi_m^{2/3}+(K_m/K_p)\phi_m^{2/3}}{(1-\phi_m^{2/3}+\phi_m)+(K_m/K_p)(\phi_m^{2/3}-\phi_m)}\right]$$

where K_E is the effective thermal conductivity, K_p

is the thermal conductivity of PMMA, K_m, is the thermal conductivity of the metal powder, and ϕ_m, is the volume fraction of the metal powder.

The experimental and the theoretical results are shown in Figures (1) and (2). In the theoretical model, the metal particles are considered to be of spherical shape, so the deviation of the experimental results may be for the uncomplete sphericity of the metal particles used in this work.

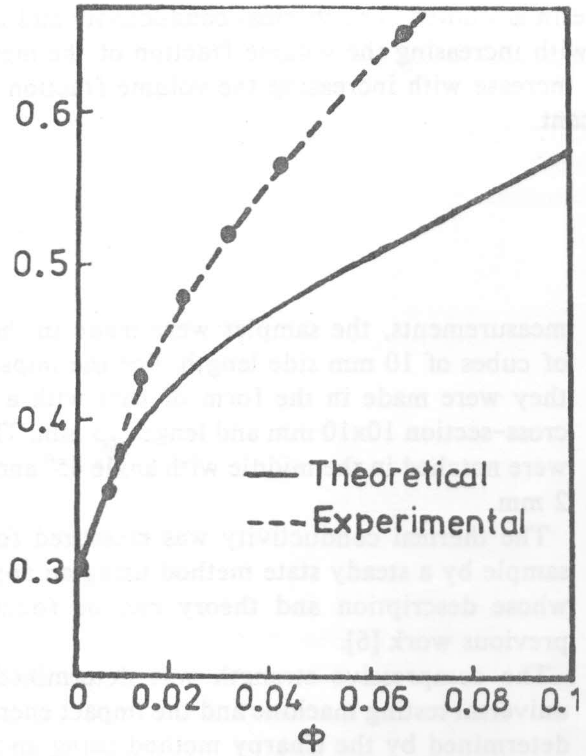

Figure 1. Thermal conductivity of PMMA-Cu vs. volume fraction of Cu.

It is evident in general that the thermal conductivity of PMMA increases with increasing the percentage volume fraction of the mixed metal phase. This is due to the fact that as the metal phase increases, there will be more overlaping of metal particles forming pathways for heat conduction. The addition of about 5.5 % copper powder can double the thermal conductivity of PMMA. The same result can be obtained by addition of about 9 % aluminium powder. Aluminium is preferable because it has two advantages, the very little cytotoxic effect and it is an inexpensive metal. In general the physical properties of the PMMA with metal powder depend on the particle size and shape of the metal particles. For the same volume fraction of a certain metal with different particle shape, the particles that forms conductive pathways within the PMMA will show higher thermal conductivity than the particles which are separated by PMMA matrix. The ideal form is reported to be elongated particles of metals with a length to diameter ratio from 75 to 125 [10].

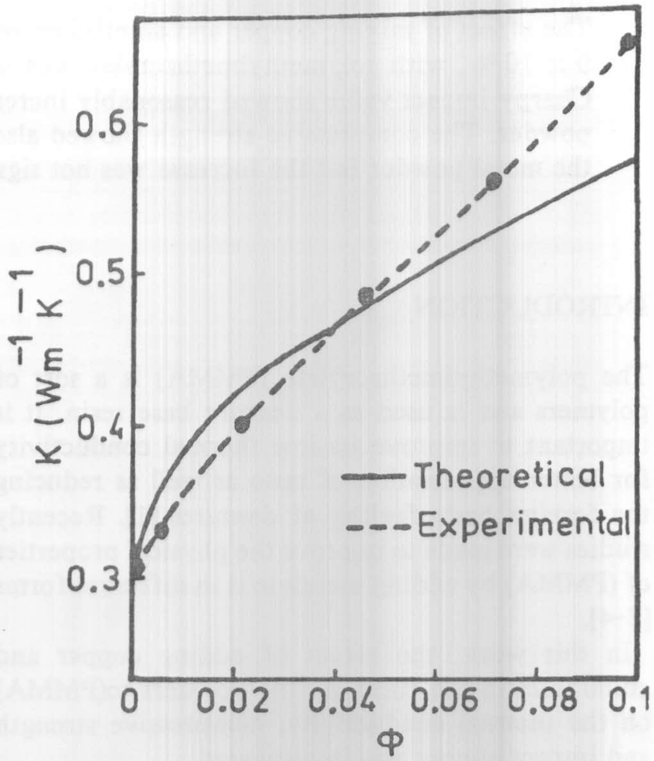

Figure 2. Thermal conductivity of PMMA-Al vs. volume fraction of Al.

The compressive strength increases with increase of the volume fraction of the metal powder as shown in Figure (3). The addition of 6 % copper increases the compressive strength by about 8.5 %, while 6 % of aluminium causes an increase of about 6.7 %.

The results of the impact test are shown in Figure (4). There is an improvement in the Charpy impact value by increasing the volume fraction of the metal phase. The addition of 6 % copper increases the impact value by 35 % while the addition of 6 % aluminium increases the impact value by 26 %.

It is clear that the addition of metal powder has a little effect on the compressive strength while it has a significant effect on the Charpy impact value.

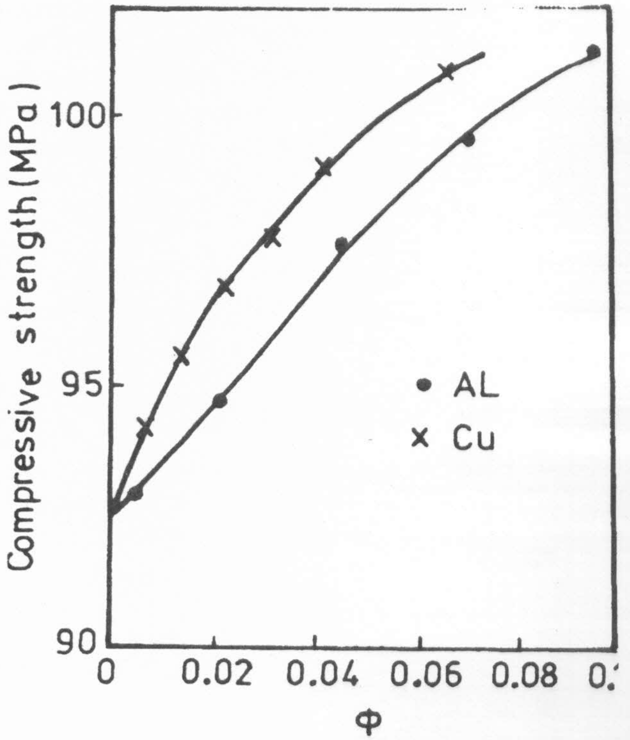

Figure 3. Compressive strength of PMMA-Al and PMMA-Cu vs volume fraction of Al and Cu.

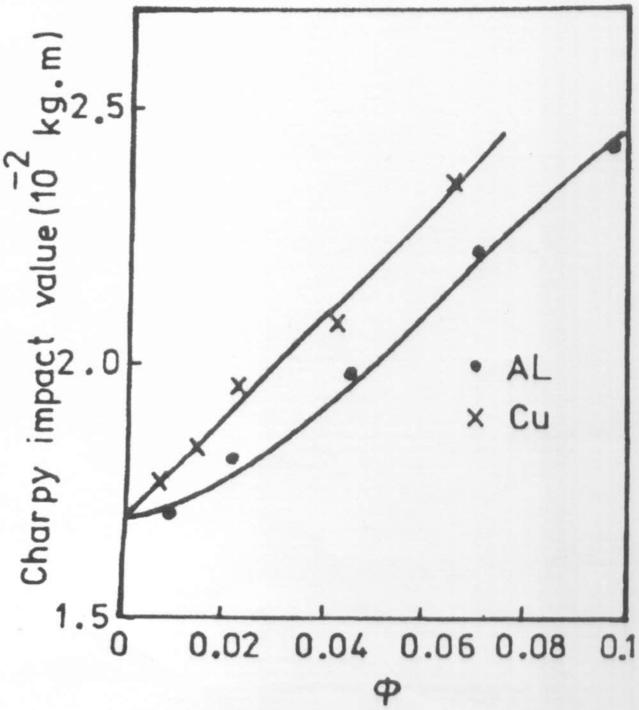

Figure 4. Charpy impact value of PMMA-Al and PMMA-Cu vs. volume fraction of Al and Cu.

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