CALIFORNIA STATE SCIENCE FAIR
2006 PROJECT SUMMARY

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Project Number
S0215

Project Title
Characterizing Oxygen Plasma and Acid Treated Polydimethylsiloxane Bonds

Abstract

Objectives/Goals
Drug delivery devices are constructed entirely from polydimethylsiloxane (PDMS). The objective is to attach the three separate layers of the device by employing oxygen plasma or acid treatment and to optimize the bond strength. Sturdy drug delivery devices will treat eye diseases such as glaucoma, macular degeneration, and retinitis pigmentosa.

Methods/Materials
Exposure to oxygen plasma alters the surface chemistry of polydimethylsiloxane, enabling covalent bonds to form between two contacting surfaces. In an acid treatment, PDMS structures are immersed in a solution of 1.2mM hydrochloric acid to increase its hydrophobicity and enable bonding to occur when two surfaces contact. For both treatments, the PDMS structures are then baked to accelerate bond formation. A pressure test is conducted to determine the bond strengths.
The variables being investigated for the effects on the bond strengths are the treatment duration, use of polar solution during assembly, baking duration, plasma machine power and pressure, acid concentration, and weighing down of the structures. Another interesting variable is the preparation of polydimethylsiloxane.

Results
For PDMS structures exposed to oxygen plasma, the baking period of 30-45mins is optimal for the temperatures of 50°C, 80°C, and 95°C. Assembling PDMS structures in ethanol bonded the structures more effectively than assembling in water or in no polar solution. Acid treated structures with longer durations of baking resulted in stronger bonds: 1.22psi for 30mins, 1.97psi for 60mins, and 2.62psi for 1440mins. Structures cured passively (overnight at room temperature) and assembled without any method of treatment can withstand an average pressure of 15.49psi, more than structures cured actively (1hr baking at 80°C).

Conclusions/Discussion
Adhesives used in attaching separate layers of drug delivery devices can clog drug channels and bring difficulty in alignment of the layers; both lead to device failure. Oxygen plasma and acid treatments are viable alternatives to adhesives. PDMS structures assembled under ethanol increases bond strengths. Bonding passively cured PDMS layers is also an alternative technique for strong layer attachments. An optimal strength between PDMS layers provides durability which will allow drug delivery devices to be refilled, reused, and leak resistant. Patients can receive targeted delivery and sufficient dosages of drugs to treat eye diseases.

Summary Statement
Drug delivery devices used for treating eye diseases are designed to reduce the negative effects that prevail in current drug delivery methods, and the performance and durability depend upon the bonding strength between the device layers.

Help Received
Mentors assisted in oxygen plasma treatment; Used lab equipment at the University of Southern California under the supervision of Dr. Meng and PhD student Ronalee Lo