Study of thermal properties of improved adhesives for medical applications

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Abstract: Adhesives are of important materials in medicine applications. These materials are used in many applications such as disposal medical devices, structural bonds, bone cement, prostheses, etc.. In order to use these materials in medicine applications, the thermal properties of these materials should be evaluated. We measured the thermal properties of the adhesive which has been modified with Hycar rubber. It is found that increasing in Hycar leads to decrease in thermal properties of adhesive. This means that we can not increase the Hycar content beyond the critical value. Because this might result in diminishing adhesive efficiency especially in human bodies where the operation temperature reaches 37 centigrade degrees.
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1. Introduction

Adhesives are of the most important materials for industries. Medical adhesives are often made of bio-consistent polymeric materials. The hardened, finished polymers are almost non-toxic. These materials are used in many medical applications such as disposal medical devices, structural bonds, bone cement, prostheses, etc.. In figure some medical applications of the cut-cure adhesives e.g. stopping bleeding, surgical operations are demonstrated. Among materials that are used in the manufacture of medical devices, there is a growing interest in polymers. Each medical adhesive has its own benefits and limitations and must be carefully matched with the appropriate application. The primary types of adhesives used in medical device applications includes Acrylics, Epoxies and Styrene polymers (Atefi *et al.* 2012a; 2012b; Davoodi *et al.* 2012). Challenges for medical devices that require skin contact can often be reduced to a wrestling match between adhesion and irritation.

An adhesive or glue is a material, usually in a liquid or semi-liquid state, that adheres or bonds items together. Adhesives come from either natural or synthetic sources. The types of materials that can be bonded are vast but they are especially useful for bonding thin materials. Adhesives cure (harden) by either evaporating a solvent or by chemical reactions that occur between two or more constituents (www.Wikipedia.com). In this paper we investigate an adhesive that cure with chemical reactions. This adhesive hardens by mixing two or more components which chemically react. This reaction causes polymers to cross-link into acrylics, urethanes, and araldites (www.Wikipedia.com; www.adhesives.org). several commercial combinations of multi - component adhesives in use in industry. In order to use these materials in medical applications, the thermal properties of these materials should be evaluated (www.adhesives.org). Numbers of factors determining the durability of structural adhesive joints have been identified and be grouped in three categories: environment, materials and stresses by da Silva *et al.* (2004) Custódio *et al.* (2009). Ratna *et al.* (2000) modified the toughened adhesive with acrylate based liquid rubber has been investigated. Other researchers used Hycar modifier for modify the properties of adhesives (Takemura *et al.* 1985). Ratna *et al.* (2001) used an acrylate-based modifier as impact modifier for adhesives. We are going to investigate Araldite-Aradur adhesive in this paper. Improving the adhesion has been preformed using Hycar modifier. This is mixed with Araldite before mixing with Aradure. We focus on thermal behavior of the adhesion using DSC. Because thermal stability is very important for High-temperature applications of an adhesive material.

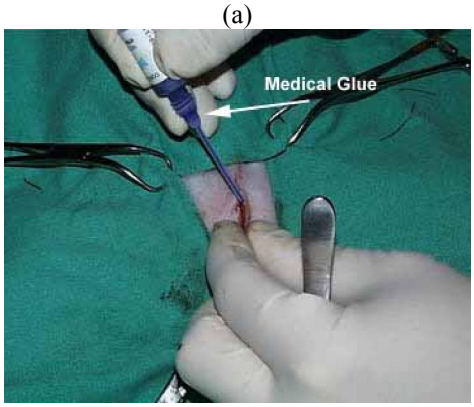
In this work improving the characteristics of adhesive used in medical external applications has been discussed. The glass transition temperature of the formulations is measured in this study. Afterwards the obtained result is reported in the following.

2. Experimental method

2.1 Araldite, Aradure and Hycar

Two materials have been used: one is Araldite-Aradure adhesive and the other is Hycar additive. Adhesive was made of two compounds: Araldite resin and the Aradure curing agent. These materials have been obtained from Shimi-Mobtaker-Peivand (Islamic Republic of Iran). The adhesive is mixed in the ratio 65 part of Araldite with 35 part of Aradure. The Hycar used is obtained from the similar source for modifying the adhesive material. This is a liquid state material that is added commonly to the adhesive for improving the adhesion properties.

(a)



(b)

Figure 1. Use of adhesives in medical applications in (a) stopping bleeding and (b) surgical operation

2.2 Making samples

First 0 to 15 percent of Hycar was appropriately weighted and six samples are made (We present formulations that are used in Table 1). Then these amounts are added and mixed with Araldite. Mixing is done to obtain uniform composition. Afterwards, appropriate amount of Aradure has been added to the mixture and we mixed it again for several minutes. Then mixture was cast into an appropriate small can. Afterwards, this is heated one hour at eighty centigrade degree. Specimens were cut out from the prepared by cutter.

2.3 Thermal property measurement

In this work the glass transition temperature is applied as an indicative for measuring the thermal strength of modified adhesives. A differential scanning calorimetry (DSC) has been used for measuring the glass transition temperature of the adhesives. The apparatus used in this study, was based on a Setaram DSC machine.

First, appropriate samples with weight of nearly 8 mg have been weighted. Then these samples have been appropriately pressed in some thin aluminum cans. Then these canned samples are heated in an appropriate heating cycle from the ambient temperature till the 130 centigrade degree. Finally, these are cooled back to room temperature (cooling cycle). The glass transition temperature (Tg) of the samples were measured automatically by the aparatus.

3. Results and discussion

It should be noted that the thermal strength of a modified adhesive is a crucial important factor for most applications. This factor is very crucial for engineering applications in factories such as aerospace, electrical, machinery etc.. This is especially very important for automotive industries and fluid conducting industries because in these applications there are some high temperature materials that might influence the performance of the applied adhesive.

It is well-stablished by previous researchers that using Hycar liquid modifier can improve the adhesion properties of Araldite-Aradure adhesive as well as other important mechanical characteristics of these glues (Takemura *et al.* 1985). However, it should be noted that using Hycar materials can effectively reduce the thermal stability and strength of a modified Araldite-Aradure adhesive.

Table 1. Samples

Sample / Material	Sample 0	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Araldite	65	65	65	65	65	65
Aradure	35	35	35	35	35	35
Hycar	0	3	6	9	12	15

In Figure 2, the glass transition temperature (Tg) of six Araldite-Aradure adhesive samples are presented for comparison. As seen from this figure, the glass transition temperature of a modified Araldite-Aradure adhesive decreases as the amount of Hycar increases. This is very important issue since this means that a user should not increase the Hycor content very much. Because this increased amount of Hycar might effectively diminish the thermal resistance and efficiency of Araldite-Aradure adhesive at high temperature.

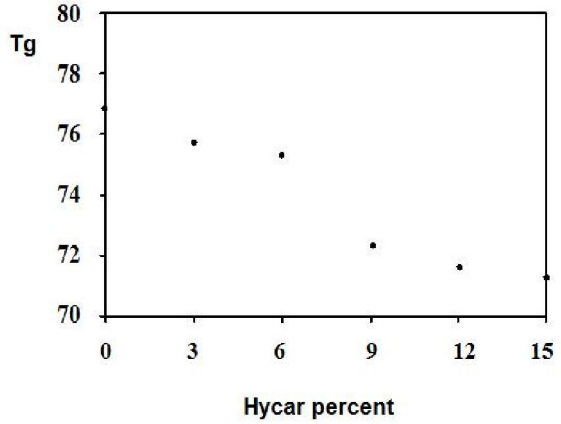


Figure 2. Tg of adhesives

4. Conclusions

Adhesives are of important materials in medicine applications such as disposal medical devices, structural bonds, bone cement, prostheses, etc. In this work we measured the thermal properties of the adhesive which has been modified with Hycar rubber. It is found that increasing in Hycar leads to decrease in thermal properties of adhesive. This means that we can not increase the Hycor content beyond the critical value. Because this might result in diminishing the efficiency of the adhesive for high-temperature application. This might causes problems when the adhesive are used in the human body temperature (37 centigrade degree).

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