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A STTUDY ON FRACTURE MECHANISM OF SiO_2/CYANOACRYLATE NANOCOMPOSITES

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ABSTRACT

In the current research role of SiO_2 nanoparticle on fracture behavior of Cyanoacrylate nanocomposite has been investigated. For this purpose Cyanoacrylate matrix reinforced with different content of SiO_2 nanoparticles were produced. Three-point bending test was performed on the standard samples. The fracture surfaces of the materials were investigated using scanning electron microscope. The results of three-point bending test show a relation between flexural strength/modulus and SiO_2 content. Microscopic evaluation proves an increase in SiO_2 content causes to change the fracture mechanism.

KEYWORDS: *Nanocomposite, Cyanoacrylate, SiO_2, Fracture Mechanism*

INTRODUCTION

In 1950s and 1960, Cyanoacrylate adhesive were used to close wounds and bond other human tissue [1]. Cyanoacrylates have found many applications in medicine and dentistry because of their bacteriostatic and haemostatic properties [2]. Because of the brittle nature and lower bursting strength failure of the shorter-chain adhesives (ethyl- and butyl-Cyanoacrylate), when device failure occurs resulting in wound dehiscence, it tends to be the result of the adhesive breaking in the middle (ie, cohesive failure) [3]. However, despite the advantages of Cyanoacrylates, drawbacks such as brittleness and short-term adhesion retentivity have limited their applicability, and consequently, they are mainly used in an emergency [4]. In order to develop technical nanocomposites inorganic nanoparticles were used by many scientists to reinforce the polymers. There was done much research on the incorporation of low and high aspect ratio nanofillers, and these have already demonstrated their capability to improve the toughness of polymers [5]. According to the literature survey done by the authors, there are not any papers concentrated on the role of nano-size particles on bending strength of Cyanoacrylate glue. Thus the main goal of the current research is concentrated on the role nano size silca on bending behavior and it will be tried to elucidate the dependency of fracture mechanism of Cyanoacrylate on silca content.

EXPEREMENTAL

The matrix of specimen used in this study were blend of Alkoxyethyl Cyanoacrylate adhesive (Loctite 460, Henkel) with 1wt% Para-toluenesulfonic acid (catalogue No. 814725, Merck), as an inhibitor and 2wt% caffeine (catalogue No. 119164, Merck) as a counteractive before polymerization. The reinforcing Silicon dioxide nano powders (Nanolin, China) was milled by mixer-mill device (Retsich MM400, Germany) for 10 min prior to their addition to Cyanoacrylate (Figure 1) to achieve nanocomposites with different silica content (i. e. 0, 0.5 and 2 wt. The standard samples with dimensions of about 3.3×10×65mm were produced. Three point bending test was applied on the specimens at room temperature. The flexural strength/modulus were measured according to ISO 1567 standards using span length of 50mm and crosshead speed of 5.0 mm/min. Flexural strength (*S*), i.e., highest stress, and flexural modulus (*E*) were calculated respectively based on Eqs. (1) - (2). Where *S* is the stress (MPa), *F* the load or force at break or at yield (*N*), *L* the span of specimen between supports (50 mm), *b* the width (10 mm), *d* the thickness (3.3mm).

$$S = 3FL/2bd^2 \quad (1)$$

$$E = 3F1L^3/4bd^3D1 \quad (2)$$

Finally the fracture surface of the samples were examined with a VP 1450-Leo scanning electron microscope (SEM).

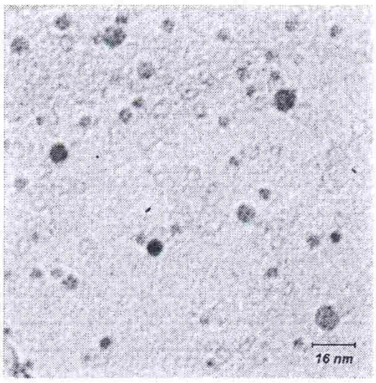

Figure1: TEM micrograph of nano-size silicon dioxide

RESULT AND DISCUSSION

Figure 2 shows the variation of flexural strength of CA versus deflection as a function of silica content. As seen an increase in SiO_2 content from 0 to 2 causes to increase flexural strength from 5.80 to 10.50 MPa that shows the dependence of flexural strength on the filler content. The detail of bending test including flexural, modulus and fracture energy are summarized in Table I. Perhaps the main reason of this variation can be referred to the fact that the modulus of silica is much higher than that of pure CA (SiO_2 (69.3 GPa), CA (6 GPa)). The achieved results show that the situation for the nanocomposites is quite different from the neat Cyanoacrylate. For example the fracture surface of neat Cyanoacrylate and the nanocomposites were compared using SEM micrographs (Figure 3). As seen in Figure 3(a) the fracture surface of neat Cyanoacrylate is almost smooth and there is no any evidence of localized plastic deformation. In Figure 3(b), both slow and rapid fracture zones are visible due to the presence of 0.5% SiO_2. The crack branching or river-like mark implies that the most amount of energy consumes due to the presence of silica content [6]. As a matter of fact the river-like marks are parallel to the crack growth direction. This river markings which mainly resulting from the crack initiation region. It is worth noting this phenomenon was reported for other materials such as shown for epoxy/SiO_2 nanocomposite [7]. In particular, a river marking can be formed by the coalescence of crazes that is developed simultaneously on different planes and then separation of the numerous crazes [8].

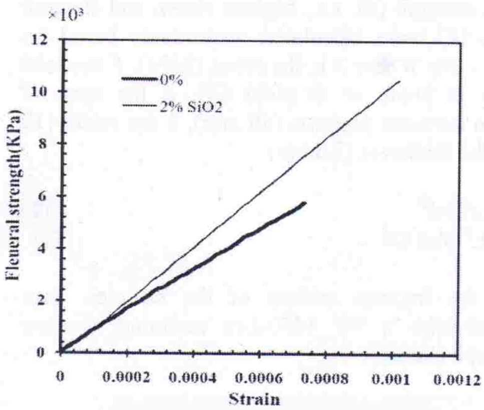

Figure2: Effect of nanoSiO2 on flexural strength of Cyanoacrylate

Table 1 Average young modulus, flexural strength and fracture toughness of Cyanoacrylate

SiO_2 Content (wt%)	Young modulus (Gpa)	Flexural strength (MPa)	Fracture energy (GPa)
0%	7.9	5.800	2.179
0.5%	6.143	8.515313	5.982
2%	10.342	10.5086	5.299

(a)

(b)

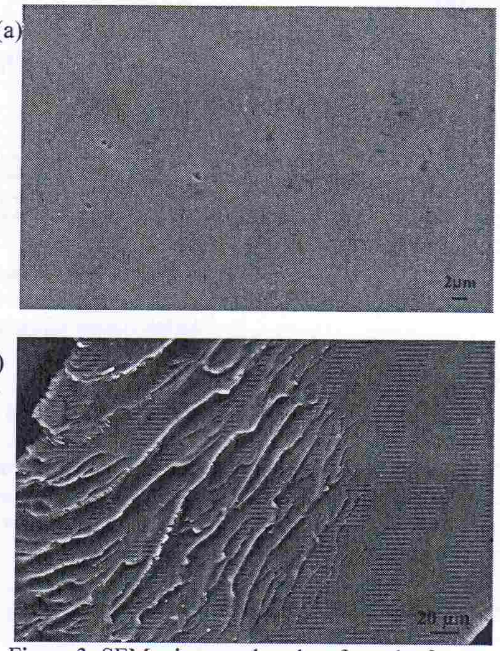

Figure 3: SEM micrographs taken from the fracture surface of begging specimen of, a) CA, b) CA - 0.5%SiO2

CONCLUSION

To investigate the deformation and fracture mechanism of Cyanoacrylate composites which are included with nano-silica particles, three point bending tests was performed. The results are summarized as below:

- Addition of SiO_2 nanoparticles to CA causes a rise in Young's modulus and a decrease in yield stress elongation at break and Flexural strength of CA/ SiO_2 nanocomposite.
- Investigation of deformation mechanism illustrates that the dominant fracture mechanism can be crack branching or river-like marks in the CA/ SiO_2 composites.

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