Effect of Temperature on the adhesive Strength of Polyvinylchloride Plates

Mahmoud Abdel-Halim Abdel-Goad

Petrochemicals Engineering Dept., Faculty of Engineering, Minia University, Egypt (E-mail:m.abdelhalim@mu.edu.eg)

Abstract: In this study Polyvinyacetate, PVAC was used as adhesive material to join two overlapped plattes of PVC. Different parameters were studied in details.. Tetrahydrofurane, THF was used instead of PVAC to join some samples. 5 wt% sand and textile fibers were incorporated into PVAC as a reinforced material. The strength of the samples joints was tested in shear by using a 2kN MTS tensile machine equipped with a video-extensometer. The results showed that, The increase in the temperature leads to increase in the adhesion force to certain extent and the optimum temperature is 50°C.

Keywords: Adhesives, PVC, Temperature, PVAC, Shear stress, Roughness, THF.

Introduction

An adhesive may be defined as a material which when applied to surfaces of material can join them together and resist separation. As a mean of joining materials adhesives have been used by mankind for many centuries. However, it is only in the last 60 years that the science and technology of adhesion and adhesives has really progressed. The main reason for this is that the adhesives employed in nearly all the technically demanding applications are based upon synthetic polymers [1-5]. Such materials possess the balance of properties that enables them to adhere readily to other materials and to have an adequate strength so that they are capable of transmitting the applied loads or forces from one substrate to the other.

Adhesives are used to locate one adherend relative to another in such a way that a load can be transmitted from one member to the other. Besides being strong enough, the joint must be sufficiently durable to resist the environmental stresses to which it is subjected during its life time. For a given glue-adherend system, its strength depends on, the way in which stresses develop around the joint, the cleanliness and smoothness of the adherend surfaces, and the way in which the glue wet them [6-8].

In many of recent adhesives research and development effort [9-20], adhesives come in many forms as structural adhesives, automotive adhesives, plastic adhesives, foam adhesives and wood adhesives. The increasing applications of fiber-reinforced organic composites as structural components in weight-critical, high technology areas like the aerospace and marine industries have placed greater demands on polymeric structural adhesive systems [21].

Experimental

Materials and preparation

Polyvinylacetate was used in this study as adhesive material to join parallel plates of PVC. The dimensions of the PVC plates were 50x5x2 mm and the plates were overlapped in a distance of 20 mm except same samples had 40 mm lap joints length. Polyvinylacetate was prepared as a semi liquid in tetrahydrofuran solvent at 60°C for about 1 hour. Followed by placing a thin film of the adhesives as sandwich in between plate-plate PVC at a surface area of 20x5 mm of the plates. Then the samples are positioned in the press mould at temperatures, pressures and times were different from one another. Some samples were prepared by the addition of textile fiber and sand to the adhesive in around 5% by weight.

Results and Discussions

The results of shear test are recorded from the instrument in table as applied load in N, elongation in mm and time in sec. <u>*Temperature*</u>

Since the interaction of the molecules of the adhesives with the surface of the adherend is of fundamental importance. The temperature plays an important role in the joining of the plates with adhesive as shown in Figure 1. The effect of temperature is clear in Figure 1 where both of the maximum applied load and the energy required to fracture the joints increase as the temperature increases in the range from 30° C up to 50° C. That because the chain segment mobility increases with temperature as a result, the intermolecular diffusion increases and the interfacial binding between adhesive and adherend becomes strong. Since the molecules are randomly kinked up to a greater degree due to molecular thermal agitation. The segments of the flexible chain have high mobility and rubber possesses, at this stage, the properties of a very viscous liquid impedes movement of the molecules relative to one another because the high degree of molecular entanglement. At temperatures in the range from 50 to 70 the energy and load start to decrease gradually but higher than 70°C the load and energy decrease and fall by many order of the magnitude as shown in Figure 1. Where the energy and load at 50°C are 251N.mm and 301N but at 100°C their values drop to be 74N.mm and 49N, respectively. This because at higher temperature the adhesion joints force becomes weak, therefore the rupture stresses decrease. Because high temperature evaporates most of the solvent of the adhesives quickly, since the boiling point of tetrahydrofurane around 78°C. And these vapors cause voids

and cracks throughout the adhesive material in between the plates surface. The presence of cracks or defects can lead to localized fracture and hence to rupture the specimen at low stresses.



Figure 1: Maxmium applied load and the required energy to break the lap joints as a function of temperature.

Conclusion

Overlapped plattes of PVC were joined in this study by using Polyvinyacetate and THF over 20 mm distance. The paramters of the preparation conditions were studied. The strength of the lap joints of the samples were tested in shear by using a 2kN MTS tensile machine equipped with a video-extensioneter. The results showed that, The increase in the temperature leads to increase in the adhesion force to certain extent and the optimum temperature is 50°C.

References

- 1. P.N.Kotiyan and P.R.Vavia, Polymer for advanced Technologies, V.13, 137, 2002.
- S.Wang, J.Wang, Q.Ji, A.R.Shultz, T.C.Ward and J.E.Mcrath, J.of Polymer Science Part B: Polymer Physics, V.38, 2409, 2000.
- 3. P.M.Stefani, S.M.Moschiar, M.I.Aranguren, C.Marieta and I.Mondragon, J. of applied polymer science, V.81, 889, 2001.
- 4. A.J.Crosby and K.R.Shull, J.of Polymer Science Part B: Polymer Physics, V.37, 3455, 1999
- 5. S. Nomura, F. Lundberg, M. Stollenwerk, K. Nakamura, Å. Ljungh, Journal of Biomedical Materials Research, V.38, P.35-42, 1997.
- 6. D.D.Eley "Adhesion", Oxford University Press, 1961.
- 7. K.Brown, J.C.Hooker and C.Creton, Macromol, Mater.Eng, 287, 163, 2002.
- 8. A.N.Rider, C.L.Olsson-Jacques and D.R.Arnott, Surface and Interface Analysis, 27, 1055, 1999.
- 9. S.W.Lye, H.S.Aw and S.G.Lee, J. of applied polymer science, V.86, 456, 2002.
- 10. H.T.Oyama, J.J.Lesko and J.P.Wightman, J.of Polymer Science:PartB:Polymer Physics, V.35, 331, 1997.
- 11. S.J. Shaw, Polymer international, V.41, 193, 1999.
- 12. D.H.Sierra, et al , J.of biomedical Materials Research, V.52, 534, 2000.
- 13. Z. Czech, Advanced in polymer Technology, V.20, 72, 2001.
- 14. E.Amendola, M.Giamberini, C.Carfagna and V.Ambrogi, Macromolecules Symposia, V.180, 153, 2002.
- 15. C.A.Finch, Polymer International, V.51, 264, 2002.
- 16. P.Bosh et al, Macromolecular Chemistry and Physics, V.203, 336, 2002.
- 17. C.Peinado, E.F.SalvadorJ.Baselga and F.Catalina, Macromolecular Chemistry and Physics, V.202, 1924, 2001.
- 18. B.S.Hayes and J.C.Seferis, J. of applied polymer science, V.76, 728,2000.
- 19. T.-H. Yoon and J.E.Mcgrath, J. of applied polymer science, V.80, 1504, 2001
- 20. P.N.Kotiyan and P.R.Vavia, Polymer for advanced Technologies, V.13, 137, 2002.
- 21. C.Gouri, C.P.R.Nair and R.Ramaswamy, J. of applied polymer science, V.74, 2321,1999.