International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 6 Issue 5, May - 2022, Pages: 35-38

The Effect of Soaking Time 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. The effect on the variation in the preparation conditions of the samples such as temperatures and pressure were investigated. The strength of the samples joints was tested in shear by using a 2kN MTS tensile machine equipped with a video-extensometer.*

Keywords: Adhesives, PVC, PVAC, Shear stress, Soaking time,Temperature, Pressure.

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].The use of adhesives in technically demanding applications has provided the spur for the research and development of new, improved materials and identified the need for, and supported, studies on the more fundamental aspects of the underlying science [22-26]. The wide range of synthetic polymers and ancillary products such as hardeners, stabilizers, toughening additives which become available over the last few decades, has enabled the adhesives technologist to develop specific adhesive formulations to meet the manufacturing and performance requirements of very diverse applications for both industrial and domestic applications. Adhesives are currently employed in industrial applications of all kinds and applications illustrated reveal that adhesives are used in some of the most critical areas in engineering structures and in some of the most demanding environments, and that they have a good history of meeting the performance and service-life requirements.

The adhesion of polyvinylchloride has been the subject of much recent research [27-31]. Because PVC has a wide range of applications including domestic and industrial pipes, cable conduit tubes, packaging and consumer goods applications, such as bottles and caps, films, toys, and footwear [32]. it is also regarded as second behind polyethylene with respect to worldwide polymer consumption.

Polyvinyl acetals acquire a unique combination of many properties as, adhesion to a wide variety of surfaces, chemical and solvent resistance to high extent in particular when crosslinked, good electrical properties, heat stability, film clarity, and physical toughness. It is extremely flexible, has a low glass transition temperature (35 ^{o}C), is used as a binder in alumina processing [33-34].

The task of this work is to investigate the role of polyvinyacetate as adhesive material in binding two parallel plates of PVC. In this work different samples will be prepared under different conditions and additives and the strength of the joints will be tested in shear.

Experimental section

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.

Measurements

Testing the joint strength in a shear is the most popular is the most popular method of testing. This test of shear stress was performed in this work for the lap joints samples at room temperature using a 2kN MTS tensile machine equipped with a video-extensometer

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 6 Issue 5, May - 2022, Pages: 35-38

so that the elongation could be measured directly in the gauge area. The sample to be tested is clamped in the instrument from two ends, then the stretching load is applied parallel to the plane of separation in such a way as to tend to make the adherents slide over the jointed faces until the joint is broken. The applied load against time and elongation were recorded.

Results and Discussions

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.

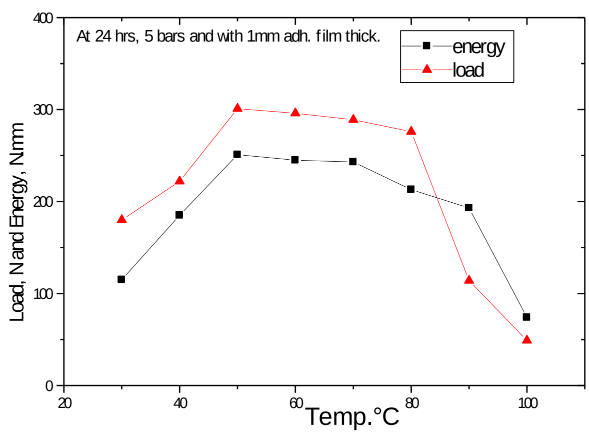

Figure 1: Maxmium applied load as a function of temperature.

Pressure

The effect of the pressing is seen in Figure 2. In this Figure the maximum applied load and the required energy to break the lap joints of the samples are plotted versus pressure. This Figure shows that the pressure improves the strength of the joints up to a certain limit (5 bars). Because the thermodynamic adhesion of the solid-liquid interface is based on the contact angle and the pressure enhances the wetness of the adherend with the adhesive. The degree of wetting can be determined from the equilibrium contact angle, but equilibrium will not normally be reached as the adhesive will be advancing and probably under pressure during the setting process. It might be thought relatively easy to obtain penetration by the pressure. In addition to the pressing eliminate microscopic bubbles which is formed from solvent vapor or entering air that giving rise to failure. Moreover pressure distribute homogeneously the adhesive material over the adherend surfaces. But at higher pressure (after 5 bars) the load and energy fall from 301 N and 251 N.mm at 5 bars to 12N and 32N.mm at 20 bars as shown in Fig.2. This because may be the adhesive material moves out of the plates under high pressure.

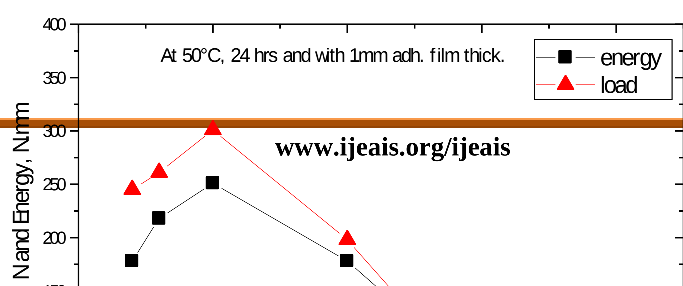

Figure 2: Maxmium applied load and the required energy to break the lap joints as a function of pressure.

Soaking Time

The maximum applied load and energy are plotted against the soaking time in Fig.3. This Figure shows an increase in both of the load and energy with time up to around 24 hours then become independent on the soaking time . Because the diffusion of the adhesives in the plates of PVC takes long time under the effect of the temperature and pressure. Since The molecular forces in the surface layers of the adhesive and substrate greatly influence the attainment of intimate molecular contact across the interface and such molecular forces are now frequently the main mechanism [6] of adhesion, and this called the adsorption theory of adhesion. Therefore, the adherend force increases by time up to 24 hours after that it becomes constant , may be because the surface of the plates becomes full saturated with the diffusion of the glue at these conditions of the preparation.

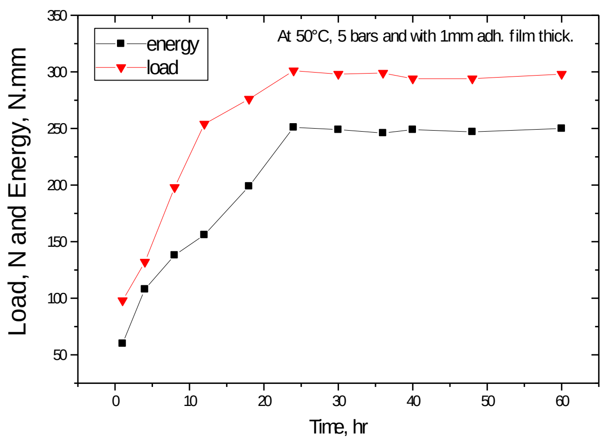

Figure 3: Maxmium applied load and the required energy to break the lap joints as a function

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-extensometer. The results showed that, The increase in the temperature, pressure soaking time lead to increase in the adhesion force to certain extent and the optimum temperature, pressure and soaking time of the glue are 50°C, 5 bars and 24 hours, respectively.

References

1. P.N.Kotiyan and P.R.Vavia, Polymer for advanced Technologies, V.13, 137, 2002.
2. 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.
22. S.P.Bunker and R.P.Wool, J.of Polymer Science Part A: Polymer Chemistry, V.40, 451, 2002.
23. A.M.Motawie and E.M.Sadek, J. of applied polymer science, V.70, 1769,1998.
24. J.H.Klug and J.C.Seferis, J. of applied polymer science, V.66, 1953,1997.
25. V.-A. Glezakou, M.Soutzidou, C.Loukoutos , I.Xexakis and K.G.Viras, J.of Polymer Science Part B: Polymer Physics, V.37, 1351, 1999.
26. R.-J. Chang, A. N. Gent, Journal of Polymer Science: Polymer Physics Edition, V.19, P.1619-1633, 1981
27. D. J. Balazs, K. Triandafillu, Y. Chevolot, B.-O. Aronsson, H. Harms, P. Descouts, H. J. Mathieu, Surface and Interface Analysis, V.35, P.301-309, 2003.
28. Y. Q. Zhu *, Y. J. Huang, Z. G. Chi, J. Of Applied Polymer Science, V56, P. 1371-1379, 1995.
29. D. A. Ernes, B. K. Garg, R. C. Williams, Journal of Applied Polymer Science, V.29, P.383-397, 1984.
30. A. N. Gent, N. Shimizu, Journal of Applied Polymer Science, V.32, P. 5385-5398, 1986.
31. Z. Czech, Advances in Polymer Technology, V.20, P. 72-85, 2001.
32. N. Sombatsompop , K. Sungsanit, Journal of Applied Polymer Science, V.89, P. 2738-2748 , 2003.
33. R.Mahajan;W.J.Koros, *Ind. Eng. Chem. Res.;* V.39, P. 2692-2696, 2000.
34. G. Sivalingam, R. Karthik, and Giridhar Madras**,** Ind. Eng. Chem. Res., V.42 , P.3647 -3653, 2003