KATHMANDU UNIVERSITY JOURNAL OF SCIENCE, ENGINEERING AND TECHNOLOGY
VOL. 5, No. II, SEPTEMBER, 2009, pp 37-41.

EFFECT OF UV-TREATMENT ON THE WETTABILITY OF POLYCARBONATE

D. P. Subedi*, R.B. Tyata, D. Rimal

Department of Natural Science (Physics), School of Science, Kathmandu University
P.O. BOX NO. 6250, Kathmandu, NEPAL.
*Corresponding author: deepaksubedi2001@yahoo.com

Received 26 September, 2008; Revised 26 December, 2008

ABSTRACT
This paper reports the results of effect of treatment of ultra-violet (UV) radiation on the wettability of polycarbonate surface. Two wavelengths of UV radiations: 254 nm and 365nm were used. Effect of treatment time on the wettability of the sample was investigated by measuring contact angle with two test liquids. Investigation showed that treatment carried out in shorter wavelength resulted a higher wettability compared to the treatment in longer wavelength. The total surface free energy of the sample calculated from two liquid model showed an increase of about 7 mJ/m^2 in the original value of 30 mJ/m^2 after 25 minutes of treatment in the UV radiation of 254 nm.

Key words: UV, polycarbonate, wettability, contact angle, surface free energy

INTRODUCTION
In recent years, polycarbonates have become very attractive business article. The world production of polycarbonates increases every year by 8-10% and nowadays it is more than 1.35 million tonnes/yr (Mappleston, 1999). Polycarbonates (PCs) have been able to replace more traditional materials like glass and metals in many products, such as automobile headlamps and stoplight lenses, corrective lenses, safety shields in windows, architectural glazing and the like. They can be applied to plastics vessels, parts of machines and in optical grades for compact discs (CDs, CD-ROMs and DVDs), optical fibers etc.

However, the low hardness, low scratch resistance and degradation by ultraviolet radiation make a modification of PC surface properties necessary. The low surface energy of polycarbonate results a poor adhesion of additional coatings which have created numerous important technical challenges to be overcome by manufacturers (Chan, *et al.*1996 and Michael *et al.* 1999). Therefore, in many applications (e.g. in industry, technology, biology and medicine) it is necessary to change or improve some of the surface properties of polycarbonate without altering its bulk properties. Several techniques have been developed to modify the polymer surfaces for improved adhesion, wettability, printability and other technologically important characteristics. The common methods of surface modification include plasma treatment, mechanical or chemical treatment; and exposure to flames, photons an ion beams.

This paper presents the modification of polycarbonate surface using UV radiation of two different wavelengths (254 nm and 365 nm). The modified surface has been characterized by measuring contact angle and subsequent calculation of surface energy.

MATERIALS AND METHODS

Preparation and treatment of sample

Lexane type polycarbonate sheets were obtained from *GE plastics,* India. Prior to treatment, these were cut to give sample size of 60 mm × 15 mm. The samples were cleaned using an ultrasonic bath for 10 minutes at an ambient temperature. These samples were dried in the air before inserting into the UV cabinet. The scheme of the treatment system is shown in the Figure

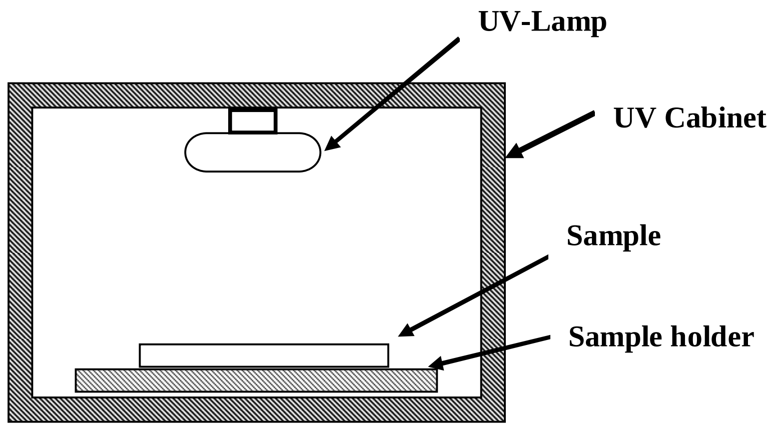

Figure 1. Schematic diagram of the UV cabinet used for the treatment of PC

Surface characterization

The effect of treatment by UV radiation was assessed by comparing the contact angle of the untreated and treated samples with doubly distilled water and glycerol. Sessile drops of volume 4 μl were made using a standard micro-syringe. The contact angle of drops with the surface of the flat polymer sheet was measured using a rame'- hart Contact Angle Goniometer model 200. This unit is equipped with standard software to analyze the drop image for the calculation of surface energy.

The surface free energy of the PC specimens was determined from the contact angles of the two test liquids with the sample surface using Owens-Wendt-Kaelble two-liquid method as represented by Equation (1); Owens and Wendt (1969).

$$\gamma_l(1+\cos\theta) = 2\left(\gamma_l{}^d\gamma_s{}^d\right)^{\frac{1}{2}} + 2\left(\gamma_l{}^p\gamma_s{}^p\right)^{\frac{1}{2}} \quad (1)$$

where γ_l, γ_l^p, γ_l^d are the total surface energy, polar component and dispersion components of the surface free energy of the liquid respectively. Similarly, γ_s, γ_s^p, γ_s^d are the values for solid under investigation. θ is the contact angle between the sample and the liquid. The experimental set-up used for the measurement of contact angle is shown in Figure 2.

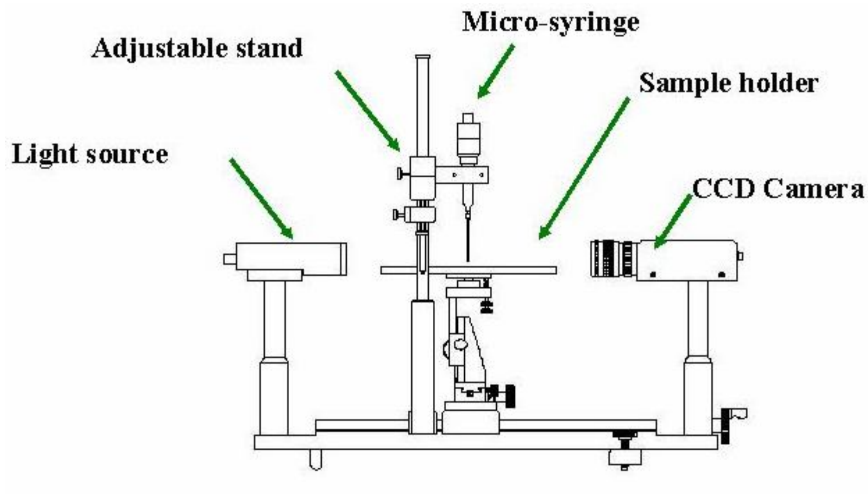

Figure 2. Schematic diagram of the rame'-hart goniometer

RESULTS AND DISCUSSION

The water contact angle on the surface of PC as a function of treatment in UV radiation of wavelengths 254nm and 365 nm are depicted in Figure 3. The water contact angle decreased from its original value of 82° to 67° after 25 minutes of treatment in UV radiation of wavelength 254 nm whereas there was only 3° reduction in contact angle after the treatment in UV radiation of 365 nm. The result clearly indicates that the treatment in shorter wavelength has appreciable effect in the wettability of the sample whereas the treatment in longer wavelength (365 nm) has only feeble effect on the wettability. The UV radiation of wavelength 254 nm corresponds to photons of energy 4.8 eV whereas the radiation of wavelength 365 nm has photons of energy 3.4 eV. The higher energy photons of short-wavelength are responsible for more effective treatment compared to the longer wavelength.It is reported that in the case of polymers, the visible radiation is weakly absorbed and doesnot produce any interesting chemical changes. The infra-red radiation ($\leq$ 0.5 eV) can be strongly absorbed but is dissipated through thermal reactions which produces heat and hence unable to produce any interesting chemical changes. The ultra-violet radiation ($\geq$5 eV) is strongly absorbed by the polymers thereby producing polymer free radicals. These polymer free radicals are active sites which can produce interesting chemical changes in the surface of the polymers (Hudis, 1974.) It was also found that the effect of treatment in these wavelength of UV is too feeble compared to the treatment in low pressure plasma as presented in our earlier results related to surface modification of polycarbonate (Zajickova *et al.*, 2003 and Subedi *et al.* 2008). Figure 4 shows the total surface free energy of PC as a function of treatment time in UV of the two wavelengths. It is evident that the treatment in UV of shorter wavelength increases surface free energy of the sample linearly with treatment time whereas the treatment in longer wavelength has virtually no effect. The values of contact angle of the two liquids on PC and the surface free energy calculated from these contact angles are summarized in Table 1. The table shows that there is an increase of about 7 mJ/m^2 in the total surface free energy of the sample after 25 minutes of treatment in shorter wavelength whereas there is no change in total surface energy of the sample even after 25 minutes of treatment in UV radiation of wavelength 365 nm. The analysis of surface free energy with its polar and dispersion components will be made in our future work.

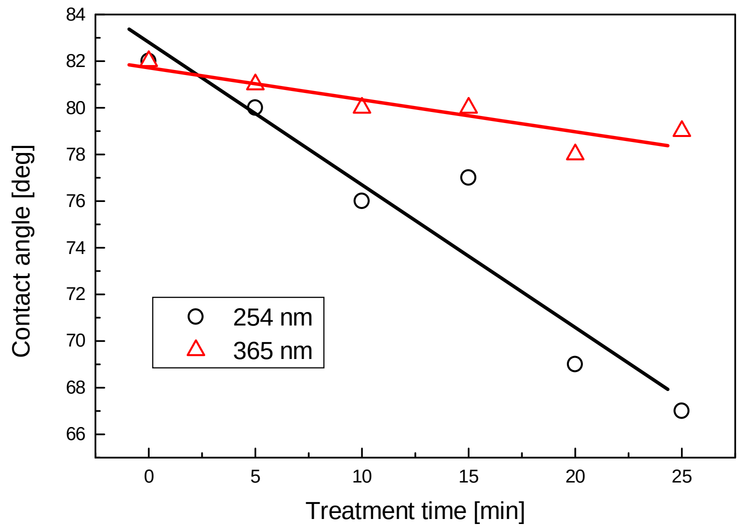

Figure 3. Plot of contact angle as a function of treatment time in UV light of two different wavelengths of 254 nm and 365 nm.

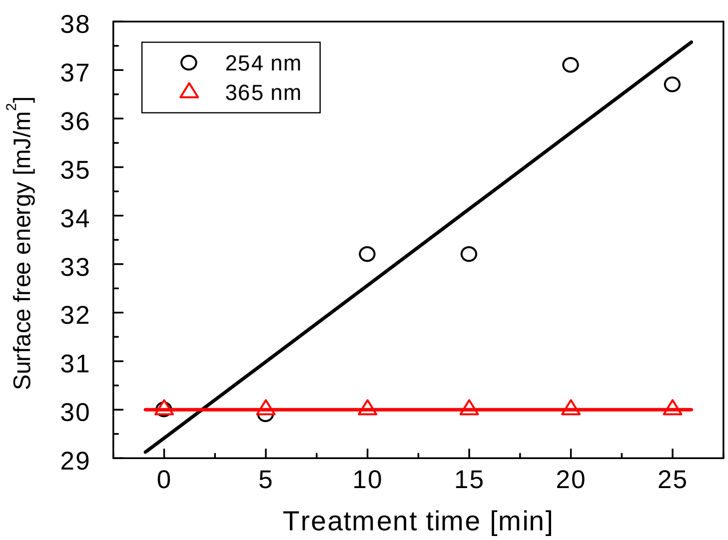

Figure 4. Surface free energy of PC as a function of treatment time in UV light of two different wavelengths of 254 nm and 365 nm.

Table1. Water contact angle on the surface of UV-treated PC sample

Treatment time [min]	**Water- contact angle [deg.]**		**Surface free energy [mJ/m^2]**	
	254 nm	**365 nm**	**254 nm**	**365 nm**
00	82	82	30.0	30
05	80	81	29.9	30
10	76	80	33.2	30
15	77	80	33.2	30
20	69	78	37.1	30
25	67	79	36.7	30

CONCLUSIONS

The present study showed that treatment of polycarbonate sample in UV radiation of shorter wavelength could be effective for the enhancement of wettability of polymers. It also revealed that the effect increases linearly with treatment time of the order of minute. The work will be extended in future to study the surface modification of PC by using other surface characterization tools in addition to surface modification.

REFERENCES

1. Mappleston, P. 1999. Long-fiber PP duels with GMT in structural parts. Modern Plastics International, 29:44, 66-68, McGraw-Hill.

2. Michael, R. M.,. Martinu, L., Clamberg –Sapieha. J. E., 1999. Adhesion Promotion Techniques: Technological Applications, Marcel Dekker, New York, pp 139-173.

3. Chan, C.M., Ko, T-M, Hiroka H., 1996. Polymer Surface Modification by plasmas and Photons. Surface Sci Rep, 24, pp1-54.

4. Owens, D. K. and Wendt, R.C., J. 1969. Estimation of the Surface Free Energy of Polymers. Appl. Polym Sci. 13: pp1741-1747.

5. Hudis, M. 1974. Plasma treatment of solid materials in Techniques and Applications of Plasma Chemistry, Capter 3. pp 113-145.

6. Zajickova, L.,. Subedi, D. P, Bursikova, V., Janca J., 2003. Study of Argon Plasma Treatment of Polycarbonate Substrate and Its Effect on Film Deposition. Acta Physica Slovacca, Vol. 53, No. 6, 489-504.

7. Subedi, D. P., Madhup D.K., Adhikari K., Joshi U.M, 2008. Low pressure plasma treatment for the enhancement of wettability of polycarbonate. Indian Journal of Pure and Applied Physics, Vol 46, pp. 540-544.