

Viscometric Study of PC / PEG blends in THF solvent and Gamma-Rays Effect on the Viscosity of PC

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Introduction

The viscosity studies of the blended polymers is a very interesting subject, because of its simplicity and importance in the characterization of the intermolecular interactions between different polymers in solution [1-12].

The compatibility between polymer-polymer has been studied by many techniques, such as, thermal analysis, neutron scattering, ultrasonic velocity, differential scanning calorimetry, refractive index, inverse gas chromatography, dynamic mechanical measurements, electron microscope, NMR method, light scattering, optical spectroscopy, but dilute-solution viscometry (DSV) is the most useful technique to study the polymer-polymer compatibility [13-25]. The importance of this method is based on repulsive or attractive inter molecular interaction between the two different polymers in solution which has a great influence on the viscosity of the polymer solution. Repulsion between the two polymers may cause shrinkage of the macromolecular coils resulting in a decrease in intrinsic viscosity, and attraction may causes swelling of macromolecular coils giving an increase in intrinsic viscosity.

The effect of radiation on the properties of polycarbonates was studied extensively using different types of radiation with different energies and fluence[26-28]. The primal effect of radiation on PC is chain scission however, at higher doses, active

ABSTRACT

In this research the intermolecular interaction between polycarbonate (PC) and polyethyleneglycol (PEG) in tetrahydrofuran (THF) solvent was studied, at 25°C using a dilute solution viscometry method (DSV). The reduced viscosity η_{sp}/C and intrinsic viscosity $[\eta]$ and viscosity interaction parameter (b) were experimentally measured, we also discuss the compatibility of a polymer mixture in terms of Δb_m , and the effect of gamma-rays on the reduced viscosity and intrinsic viscosity and Huggins constant of (PC). The results show that the relation between η_{sp}/C and C is liner within $C=(0.9-2)g/dl$, and viscometric constant K_H decreases with irradiation time while $[\eta]$ increases with T_{irr} .

site or branching points created by scission may lead to intermolecular crosslinks.

The goal of the present study was the viscosity measurements and compatibility of PC,PEG and PC/PEG blends ,in THF ,and the effect of γ -rays on the viscosity of PC .

Experimental part

The viscometric behavior of polycarbonate (PC) and polyethyleneglycol (PEG) and their blends solutions were determined at 25°C \pm 0.1 by using Cannon-Fenske type capillary viscometer [29].

Solutions were prepared by mixing the calculated quantities of polymer solution in different weight ratios in THF solvent up to concentration (C) of 2.0 g/dl. Five sample solutions of lower concentrations were prepared by adding appropriate aliquots of solvent to the solution.

The efflux time of each solution was determined as the average of several reading. The specific viscosity η_{sp} was calculated at different concentration. The intrinsic viscosity $[\eta]$ and viscometric interaction parameter, b were determined by extrapolation to infinite dilution and from the slope of the linear plots, respectively, of Huggin's plot i.e η_{sp}/C versus C. In

this work also the PC solutions at the concentration 2 g/dl were irradiated for seven days by gamma-rays

from CS¹³⁷ source of activity 1μ ci and energy 0.662 MeV.

Results and discussion

The plots of the reduced viscosity η_{sp}/C versus C for PC, PEG and PC/ PEG blends with weight fractions of 0.7,0.5,0.3 in THF at 25°C are shown in fig.1. All the plots are linear in the concentration range (0.9-2.0) g/dl, while reduced viscosity increases when the concentration is less than 0.9 g/dl which is due to the change of polymer solution from the non-Newtonian flow to Newtonian flow[30].

The specific viscosity of a mixed polymer solution $\eta_{sp,m}$ was developed by Krigbaum and wall as shown[31].

$$\eta_{sp,m} = [\eta]_1 C_1 + [\eta]_2 C_2 + b_{11} C_{11}^2 + 2b_{12} C_1 C_2 + b_{22} C_{22}^2 \dots \dots (1)$$

Where $[\eta]_1$ and $[\eta]_2$ are the intrinsic viscosity of polymer components 1 and 2, respectively, C_1 and C_2 are the concentrations of components 1 and 2 respectively, and b_{11} , b_{22} are the specific interaction parameters of components 1 and 2 in the binary system (polymer-solvent). b_{12} is the specific interaction parameter of components 1 and 2 in solution which is expressed as

$$b_{12} = (b_{11} b_{22})^{1/2} \dots \dots \dots (2)$$

The interaction between polymer 1 and 2 is given by the equation:

$$\Delta b = b_{12} - (b_{11} b_{22})^{1/2} \dots \dots \dots (3)$$

Δb is the intermolecular interaction between polymer 1 and 2^[6].

The plot of reduced viscosity versus concentration gives a straight line, and Huggins proposed the below equation^[32]

$$\eta_{red} = [\eta] + K_H [\eta]^2 C \dots \dots \dots (4)$$

Where $[\eta]$ and K_H are the intrinsic viscosity and Huggins constant respectively.

The intrinsic viscosity $[\eta]$ and viscometric interaction parameter (b) and the degree of polymer - polymer compatibility Δb_m can be calculated by extrapolating η_{sp}/C to zero concentration, and tabulated in table (1) and drawn in fig.2 and 3. It is clear from fig. 2 there is a linear relationship between $[\eta]$ and weight fractions of PC/PEG in THF at 25°C.

Table 1: Viscometric data i.e $[\eta]$, b and Δb_m of PC/PEG blends in THF at 25°C.

W _{pc}	$[\eta]$ (dl/g)	b (dl/g) ²	Δb_m
1	0.599	0.0857	0.02715
0.7	0.497	0.0874	0.0761
0.5	0.389	0.052	0.0407
0.3	0.275	0.015	0.0037
0	0.1165	0.0015	-0.01855

From fig.3 we show that the plot Δb_m and $w_{PC/PEG}$ is a linear and intercept at the negative value of Δb_m .

When the weight fraction of PC/PEG is more than 0.28 we get positive Δb_m which indicates that both polymers are compatible. While when $\Delta b_m < 0$ indicates that they are incompatible which is in the range less than 0.28 weight fraction, and this could be attributed to the strong repulsive intermolecular interactions between the polymer chains in THF [6,32].

The gamma-ray effect on the reduced viscosity η_{sp}/C

versus concentration C is shown in fig. 4. It is clear that crosslinking takes places, the explanation for behaviour appears to be that during irradiation, radicals are formed in the polycarbonate (PC) and which reacts with the molecules and leads to an increase in the reduced viscosity, and so increases the intrinsic viscosity $[\eta]$ [29]. as shown in fig .5.

The values of Huggin’s viscometric constant K_H has been determined from the slope of η_{sp}/C versus C in

fig. 4 and plotted as a function of irradiation time, fig. 6, from this figure K_H decreases with irradiation time, while η_{sp}/C increases with increasing irradiation time

as shown in fig. 7, which is due to the free radicals and ions formed during irradiation of (PC) by gamma-rays which join together to gives large series of (PC) and this leads to crosslinking.

Conclusion

In this work we concluded that the relation between η_{sp}/C and C is linear within C = (0.9-2) g/dl while it increased when C < 0.9 g/dl., and $[\eta]$ increases with increasing $w_{PC/PEG}$. The polymers (PC and PEG) are compatible when $\Delta b_m < 0$ and incompatible when $\Delta b_m > 0$, and viscometric constant K_H decreases with the irradiation time in the limit of irradiation, while $[\eta]$ and η_{sp}/C increases with T_{irr} .

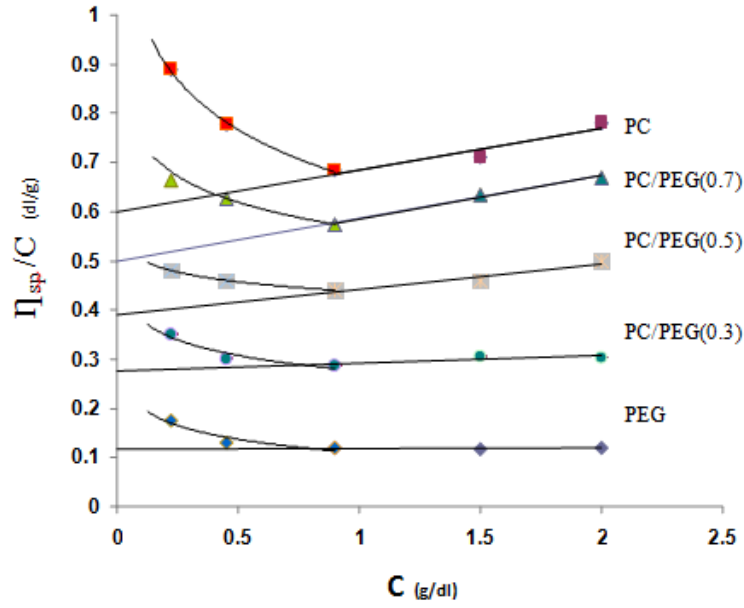


Fig.1 Reduced viscosity η_{sp}/C versus concentration (C) for PC, PEG and PC/PEG blends .

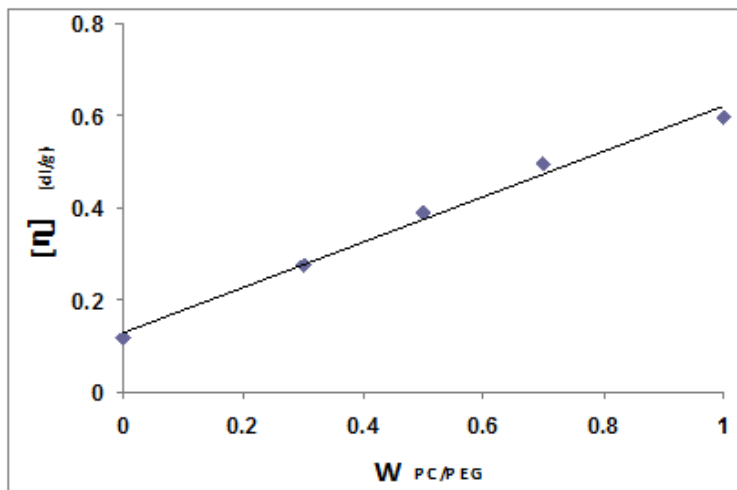


Fig.2 Intrinsic viscosity $[\eta]$ versus weight fractions of PC/PEG in THF.

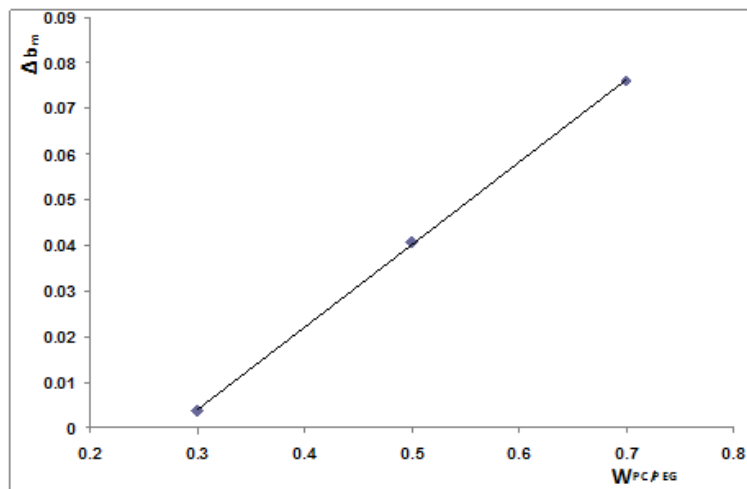


Fig.3 Compatibility magnitude versus different weight fractions of PC/PEG blends .

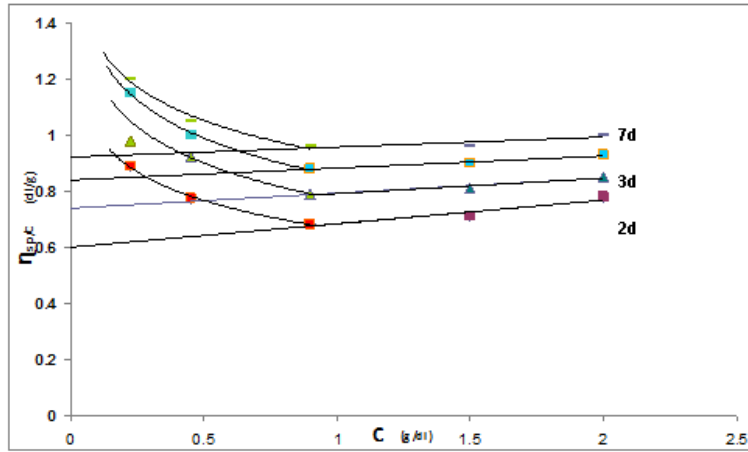


Fig.4 Reduced viscosity η_{sp}/c versus concentration for PC irradiated by gamma-rays from CS^{137} source.

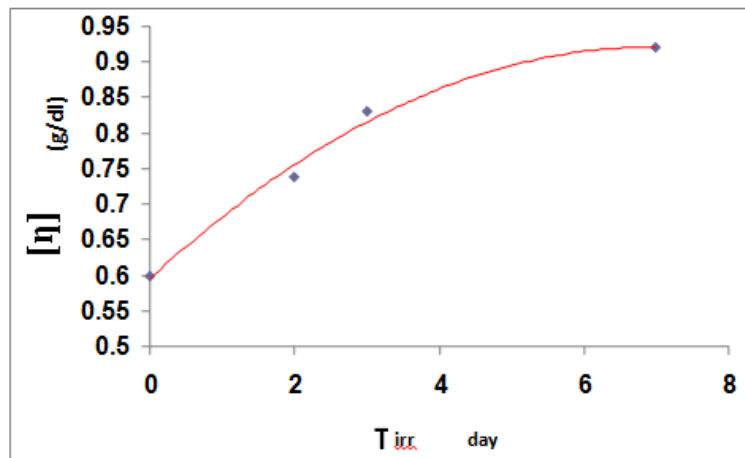


Fig.5 Intrinsic viscosity $[\eta]$ versus time of irradiation for PC.

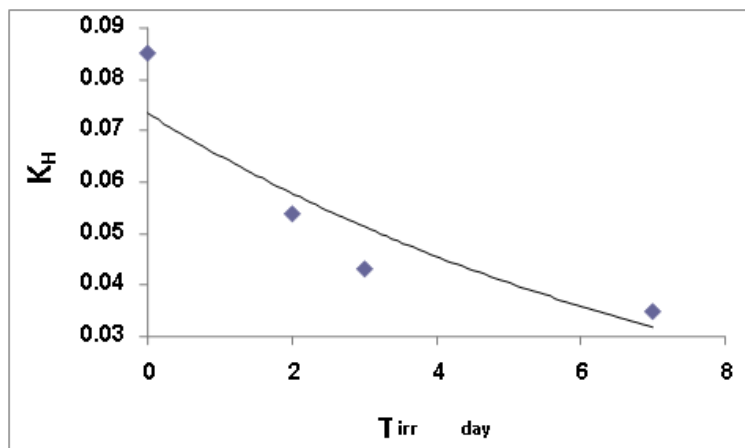


Fig.6 Viscometric constant K_H versus time of irradiation for PC.

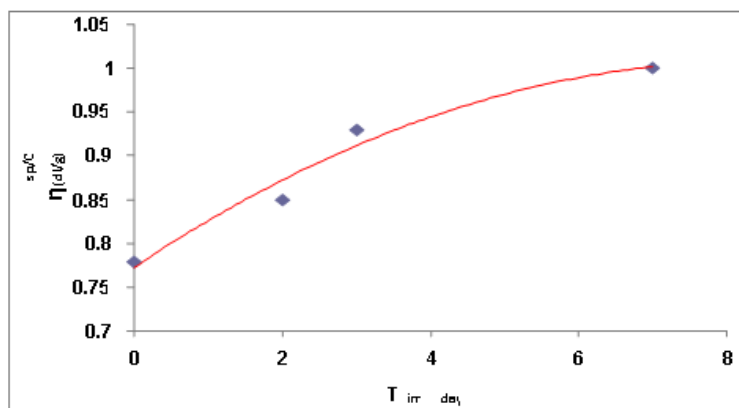


Fig.7 Reduced viscosity η_{sp}/c versus time of irradiation for PC concentration 2g/dl.

References

- [1] Mohammad, S.K.; Raina, A.Q. and Mian, S.W. (2008). *Afr. Journal pure Appl. Chem.*, **2**:041-045.
- [2] Omar, M.; Rajai, B.; Jamil, K.J.S.; Hani, H. and Awin, El-k. (2003). *chin. J. polym. Sci.*, **21**:15-19.
- [3] Zhang, Y.C. (2002). *Eur. Polym. J.*, **38**:333.
- [4] Saha, S. (2001). *Eur. Polym. J.*, **37**:2513.
- [5] Haiyang, Y.; Pingping, Z.; Minjun, H.; Shengli, M. and Yuanyuan, W. (2000). *Eur. Polym. J.*, **36**:949.
- [6] Garcia, R.; Melad, Q.; Gomez, C.M; Figueruelo, J.E. and Campos, A. (1999). *Eur. Polym. J.*, **35**:4.
- [7] Mathew, M.; Ninan, K.N. and Thomas, S. (1998). *Polymer*, **39**:6235.
- [8] Abdel-Azim, A.A.; Bourtos, W.Y. and Abdel-Bary., E.M. (1998). *Polymer*, **39**:2543.
- [9] Jiang, W.H. and Han, S.J. (1998). *J. Polym. Sci, part B, Polym. Phys.*, **36**:1275.
- [10] Ashok, K. et al. (2011). *Mac. Mol. Theo. Simu.*, **20**:19-30.
- [11] Catherine, A.K.; Andrew, N.; Iisbeth, I. and Kevin, M.S. (2012). *Adv. Fun. Mat.*, **22**:1984-1991.
- [12] Halder, R.S.; Deopura, B.L. and Miro, A. (2004). *Polym. Eng. Sci.*, **29**:1766-1773.
- [13] Nita, L.E.; Chiriac, A.P.; Neamta, I. and Berea, M. (2011). *Phys. Engi. Asp.*, **374**:121-128.
- [14] Thinglu, M.; Guorong, S. and Songmin, S. (2010). *Journal Appl. Polym. Sci.*, **118**:2572-2581.
- [15] Nita, L.E.; Chiriac, A.P.; Neamta, I. Berea, M. (2009). *Phys. Engi. Asp.*, **348**:254-262.
- [16] Murat, M. and Ali, G. (2006). *Journal Appli, Polym. Sci.*, **100**:4587-4594.
- [17] Kumar, M.S.; Bhat, D.K. and Renganathan, N.G. (2009). *Journal Apply. Polym. Sci.*, **111**:452-460.
- [18] Kavlak, S.; Can, H.K. and Guner, A. (2004). *Journal Appl. Polym.*, **94**:453-460.
- [19] Rajulu, A.V. and Reddy, R.L. *Journal Int. Polym. Mater.*, **47**:469-476.
- [20] Erika, F.; Eniko, F. and Zoltan, L. (2012). **13**:737-755.
- [21] Yang, H.; Zhu, P.; Wang, S.; Zeng, Y. and Gou, Q. (1998). *Journal Eur. Polym.*, **34**:1303-1308.
- [22] Moore, W.R. and Uddin, M. (2003). *Eur. Polym. Journal*, 5245.
- [23] Cemil, A. and Ahmet, S.O. (2006). *Journal Alche.*, **52**:3310-3314.
- [24] Mamza, P.A.A.P. and Folaranmi, F.M. (1996). *Journal Eur. Polym.*, **32**:909.
- [25] Zhu, P.P. (1997). *Journal Eur. Polym.*, **33**:411.
- [26] Lounis, M.Z.; Fromm, M.; Barillon, R.; Chambaudet, M. and Allab, M. (2003). *Journal Randi. Meas.*, **36**:615.
- [27] Malinowski, K.; Skladnik, E. and Sadowski, M. (2005). *Journal Radi, Meas.*, **40**:371.
- [28] Nidal, D.; Toshiyuki, I.; Fuminobu, S. and Yohei, I. (2007). *Journal Nucl Inst. Meth.*, **572**:826.
- [29] Buni, M.S.; Solyman, W.A. and Ali, S.A. (2013). *Journal Edu. Sci.*, **26**:40-48.
- [30] Tager, A. (1978). *Moscow physical chemistry of pohymers.*
- [31] Kribaum, W.R. and Wall, F.T. (1950). *Journal Polym. Sci.*, **5**:505.
- [32] Abbas, M. and Reza, A. (2010). *Journal Chem. Eng. Data*, **55**:2537-2541.

دراسة المزيج اللزوجي للبولي كاربونيت (PC) والبولي اثيلين كلايكول (PEG) في مذيب
تتراهايدروفوران (THF) وتأثير أشعة كاما على لزوجة البولي كاربونيت (PC)

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الملخص

في هذا البحث تم دراسة التفاعل الجزيئي بين البولي كاربونيت (PC) والبولي اثيلين كلايكول (PEG) بعد اذابتهما في مذيب تتراهايدروفوران (THF) في درجة الحرارة $25^{\circ}C$ باستخدام طريقة اللزوجة للمحاليل المخففة (DSV). حيث تم حساب عمليا اللزوجة المختزلة (η_{sp}/C) واللزوجة الذاتية $[\eta]$ وعامل التفاعل (b)، كما تم دراسة الامتزاج في خليط البوليمر بدلالة العامل Δb_m ، وكذلك تأثير أشعة كاما على اللزوجة المختزلة والذاتية وثابت هيوكن للبولي كاربونيت (PC). النتائج أظهرت أن العلاقة بين اللزوجة المختزلة والتركيز خطية عندما $C=(0.9-2)g/dl$ ، وثابت هيوكن K_H يقل بزيادة زمن التشعيع بينما اللزوجة الذاتية $[\eta]$ تزداد بزيادة T_{irr} .