N,N-dibutyl lauramide as new alternative plasticizer for polyvinyl chloride

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In this study, N,N-dibutyl lauramide (DBLA) has been synthesized and tested as new plasticizer for polyvinyl chloride (PVC), alternative to common toxic phthalate esters. It has been found that DBLA has excellent compatibility with PVC and efficiently reduces its glass transition temperature from 83,5 to -7,7 ºC at plasticizer content 30 wt%.

Keywords – polyvinyl chloride, plasticizer, fatty acid dibutylamide, glass transition, thermal stability

Introduction

Until recently, phthalate esters were most commonly used plasticizers for polyvinyl chloride (PVC). However, phtalates have been identified as reproductive and developmental toxicants, as well as probable human carcinogens [1]. Thus, the development of new phthalate-free PVC plasticizers is of great demand. Fatty acid dialkylamides have been reported as efficient primary PVC plasticizers which can be prepared from vegetable oils or their derivatives [2]. Further research, however, showed reduced heat resistance of plasticized PVC compositions based on unsaturated fatty dialkylamides.

The aim of this study was to evaluate plasticizing efficiency, as well as migration resistance of new saturated fatty acid dibutylamide, namely N,N-dibutyl lauramide.

Experimental section

N,N-dibutyl lauramide (DBLA) was synthesized according to following scheme.

$$CH_3(CH_2)_{10}COCl + HN(C_4H_9)_2 \xrightarrow[CH_2Cl_2]{N(C_2H_5)_3} CH_3(CH_2)_{10}CON(C_4H_9)_2$$

Polyvinyl chloride Ongrovil® S5258 (BorsodChem, Hungary) was used for the preparation of plasticized compositions. PVC/DBLA composites containing 20 and 30 wt% of plasticizer were prepared by solvent-cast film method using dichloroethane as a solvent.

The tensile tests were carried out using a universal tensile test machine P-50 (Milaform) at a deformation rate of 10 mm/min. According to mechanical testing data, PVC/DBLA films have lowered tensile strength, as well as significantly higher elongation at break, compared to neat PVC (Table 1). The last parameter indicates an improved flexibility imparted by plasticizer.

Table 1

Mechanical properties of PVC/DBLA films

Sample	Tensile strength, MPa	Elongation at break, %
PVC control	37,5 ± 1,5	16,5 ± 3,5
PVC/20% DBLA	17,8 ± 3,5	191,6 ± 4,5
PVC/30% DBLA	12,8 ± 2,0	211,5 ± 5,5

Thermal gravimetric analysis (TGA) was performed using a TGA Q500 (TA Instruments). About 10 mg of each sample was heated from 30 °C to 700 °C with a heating rate of 10 °C/min under an air atmosphere. According to the TGA data, PVC/DBLA composite has a thermal

decomposition point (which was defined as the temperature of 5% weight loss ($T_{\Delta m=5\%}$)) at 221 °C that is very close to that for neat PVC (Table 2).

Table 2

TGA data for plasticized PVC composition

Sample	$T_{\Delta m}$=5%, °C	$T_{\Delta m}$=10%, °C	$T_{\Delta m}$=20%, °C	$T_{\Delta m}$=50%, °C
PVC control	226	257	277	301
DBLA	182	203	228	268
PVC/30% DBLA	221	227	235	265

Plasticizing effect of DBLA on PVC was studied using DSC Q2000 TA Instrument analyzer. The heating process was performed from -90 to 150°C at 20 °C/min. Glass transition curves obtained for PVC/DBLA compositions are illustrated in Fig. 1. The neat PVC had glass transition temperature T_g of 83,5 °C. T_g decreased significantly on addition of DBLA plasticizer, reaching the value -7,7 °C for PVC/DBLA (30%).

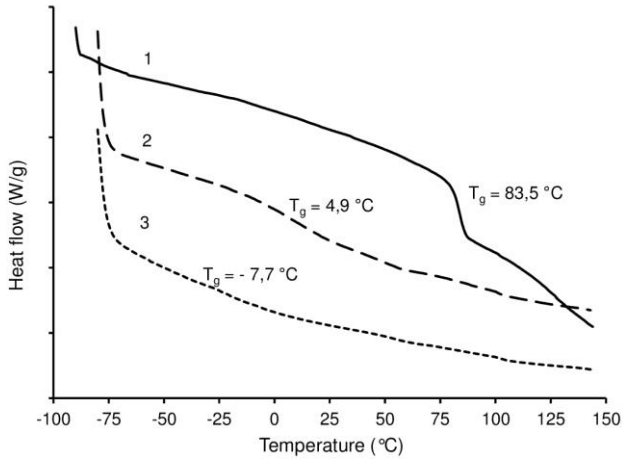

Fig.1. Glass transition curves: 1 - PVC, 2 - PVC/DBLA (20%), 3 - PVC/DBLA (30%)

For evaluation the resistance of plasticizer to migration, PVC/DBLA films of 80 x 80 mm size were placed between two lists of filter paper. The sandwiched materials were kept in contact by placing them between glass plates. The migration of plasticizer was studied at 25 °C over 21 days period. The amount of plasticizer that migrated from PVC film was found to be 1,5% from its total content.

Conclusion

Thus, it can be concluded that N,N-dibutylamide of lauric acid (DBLA) is an efficient, primary plasticizer for PVC resin. The plasticizing efficiency of DBLA is very close to that of common phthalate esters. Moreover, PVC/DBLA compositions showed excellent thermal stability, as well as high migration resistance of plasticizer from polymer matrix.

References

[1] "Phtalates and their alternatives: health and environmental concerns", Technical Briefing, Lowell Center for Sustainable Production, University of Massachusetts Lowell, January 2011.

[2] R. R. Mod, F. C. Magne, E. L. Skau, "N,N-dialkylamides of long chain fatty acids as plasticizers", *Journal of the American Oil Chemist's Society,* vol. 42, pp. 941-944.