COMPARATIVE STUDY OF EFFICIENCY OF NUCLEATING AGENTS IN PA-6

I. Mudra and G. Balázs

Department of Plastics and Rubber Technology, Technical University of Budapest, H-1521 Budapest Műegyetem rkp. 3, Hungary

(Received March 10, 1997; in revised form June 5, 1997)

Abstract

The isothermal and anisothermal crystallization of nucleated polyamide-6 (PA-6) was investigated by DSC. A comparative study was made of twelve potential nucleating agents, including some commercial products for PA-6 and polypropylene. The amide wax processing aid lubricant originally introduced into the polymer was found to exhibit a marked nucleation ability.

Keywords: crystallization, DSC study, nucleating agents, PA-6

Introduction

Polyamide-6 (PA-6) is a widely used, relatively cheap crystalline engineering thermoplastic which has a moderate crystallization rate similar to that of polypropylene (PP).

Nucleating agents are mostly used in these two polymers. These additives normally increase the rate of crystallization, which shortens the cycle time in injection moulding, improving the productivity of the process, decreases the spherulite size and results in the development of a more uniform structure with enhanced mechanical properties [1–4].

Thousands of different materials have been studied as potential nucleating agents in the case of PP, but a literature search reveals that less attention has been paid to the nucleation of PA-6. Nevertheless, a patent dealing with the fillers of PA-6 more than 50 years ago claimed an appreciable nucleating effect [2]. Numerous commercial nucleated PA grades are currently on the market, e.g. several materials of Allied Signal Co.; Adell; EMS; Nylon Corp.; Texapol, etc. [5]. In basic monographs, several materials are mentioned as efficient nucleating agents in PA-6:

- kaolin
- lead(II) phosphate
- sodium phenyl phosphinate
- polyethylene terephthalate
- polyamide 6,6
- colloidal silica
- molybdenum(IV) sulfide
- iron sulfide
- titanium(IV) oxide
- talc

The nucleating effects of some new materials have been verified:
- poly(4,4-diphenylsulfone terephthalamide) [6]
- polyvinylidene fluoride [7]
- montanates [8]
- phthalocyanine [9]
- fatty acid amide [10]
- metal diaryl phosphates [11]
- surface-treated montmorillonite [12]

An on-line literature search demonstrated that a great number of materials may be used as nucleating agents in PA-6, but their mechanisms are not known, and extensive studies to compare tens or hundreds of potential nucleating agents have not been made at all for PA-6.

The main aims of the present study were:
- a comparative study of some potential nucleating agents, with a commercial grade PA-6 as base polymer
- a check on the activity of some nucleating agents of PP in PA-6 (since more information is available on the mechanism and efficiency of nucleating agents in PP).

**Experimental**

The base polymer used was an injection moulding grade material produced by 'Viscosa RT' (Hungary), containing 0.5 wt% amide wax lubricant. The nucleating agent content was 0.1, 0.5 or 1.0 wt%. The additives were introduced into the polymer with a Brabender ZSK 42-7 twin-screw extruder at 250°C.

The nucleating agents studied and their abbreviations are listed below:
- Two different grades of calcium stearate (CAN and CAS)
- Polyethylene terephthalate (PET)
- Wyoming bentonite with high montmorillonite content (NAB)
- CaCO₃ with high surface area, precipitated (Socal, Solvay Co.) (SU)
- Colloidal silica, normal grade (Degussa Co.) (A200)
- Colloidal silica, surface-modified (Degussa) (R972)
- Talc (Luzenac Co.) (LT)

*J. Thermal Anal., 52, 1998*