Polymer 70 (2015) 19–29

Contents lists available at ScienceDirect

Polymer

journal homepage: www.elsevier.com/locate/polymer

Role of ethanol concentration on drawing and infusion behavior of poly(ethylene terephthalate) filaments upon cold drawing

Rina Khanum [a], Dong Woo Go [a], Wataru Takarada [a], Arun Aneja [b, 1], Takeshi Kikutani [a, *]

[a] Department of Organic and Polymeric Materials, Tokyo Institute of Technology, 2-12-1-S8-32, O-okayama, Meguro-ku, Tokyo 152-8552, Japan
[b] Department of Engineering, East Carolina University, Greenville, NC 27858, USA

ARTICLE INFO

Article history:
Received 23 April 2015
Received in revised form
2 June 2015
Accepted 3 June 2015
Available online 5 June 2015

Keywords:
Poly(ethylene terephthalate)
Ethanol/water solution
Infusion
Dye
Drawing

ABSTRACT

This paper describes the drawing and concomitant infusion behavior in low oriented PET filament drawn at room temperature in ethanol/water solution of various ethanol concentrations. Increasing concentration of ethanol greatly increased the number of necks on filament, and reduced the yield and drawing stresses. With increasing concentration of ethanol the infusion of ethanol into filament was increased, and a well-developed crystalline structure was formed. Shrinkage reduction of filament with increasing ethanol concentration was also investigated. Infusion of dye molecules in filament was also increased with raising of ethanol concentration. Color spectrum study confirmed that dye molecules infused only in drawn parts of filament and undrawn parts showed 100% transmittance.

1. Introduction

Poly (ethylene terephthalate) (PET) filament is widely used in textile industry. In this study to understand the role of ethanol concentration and infusion we used low oriented amorphous PET filament. Under tensile stress, drawing (stretching) of polymer filaments in organic solvent can form a multiple necking effect on filament [1–4]. During stretching in solvent, a microporous structure can be formed [4–6]. In differential scanning calorimetry study, filaments containing solvent can show an endothermic peak comparatively at lower temperature than melting temperature; this endothermic peak is caused by the vaporization of solvent upon heating [7]. There are several studies about solvent induced crystallization of amorphous polymer [8–13].

Moreover, organic solvent is of great importance for dyeing of PET filament. Organic solvent is employed in aqueous medium for disperse dye bath assistance along with temperature to enhance the dyeing rate in fiber [14–16]. The solubility of dyes in water increases with increase of solvent concentration [17]. In solvent dyeing, organic solvents are used as an alternative dyeing method of water media dyeing [18–24]. Disperse dyes show greater solubility in solvents than in water [22,25,26].

In our previous study, we found that drawing of filaments at room temperature in air showed formation of a single neck with amorphous orientation in filaments [3]. However, filament drawing in organic solvent caused multiple necking effect and crystalline structure formation.

In this paper, we stretched filaments at room temperature in ethanol and in aqueous ethanol by mixing ethanol and water with different volume fractions. The selection of a water-ethanol mixture is based on many factors: (1) miscibility of ethanol with water, (2) water induced crystallization in PET filament [27], (3) reduction of the cost of production for industrial use, and (4) reduction of the chance of flammability.

In this current research, we investigate the effect of ethanol concentration on drawing and necking behavior of low oriented PET filament. We also study the effect of ethanol concentration on infusion of ethanol and dye molecules in filament, along with impact on structural orientation of filaments.

* Corresponding author.
E-mail addresses: khanum.r.aa@m.titech.ac.jp (R. Khanum), go.d.aa@m.titech.ac.jp (D.W. Go), takarada.w.aa@m.titech.ac.jp (W. Takarada), anejaap@gmail.com (A. Aneja), kikutani.t.aa@m.titech.ac.jp (T. Kikutani).
[1] Formerly, Senior Research Associate, DuPont Company, USA.

http://dx.doi.org/10.1016/j.polymer.2015.06.003
0032-3861/

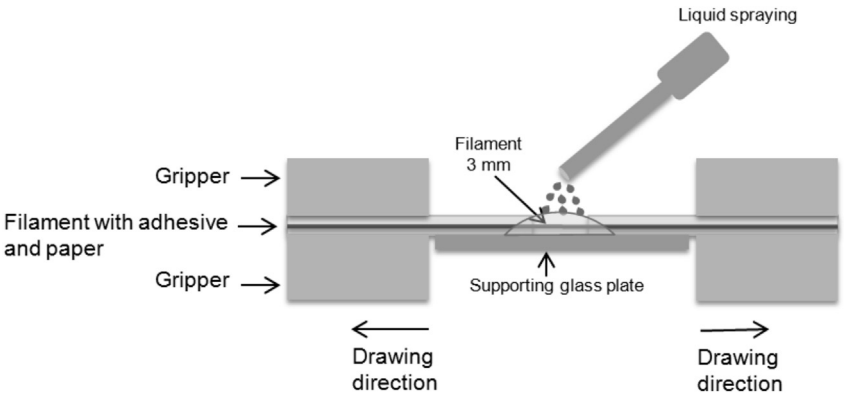

Fig. 1. Schematic diagram of mini tensile tester for stretching filament in solvent.

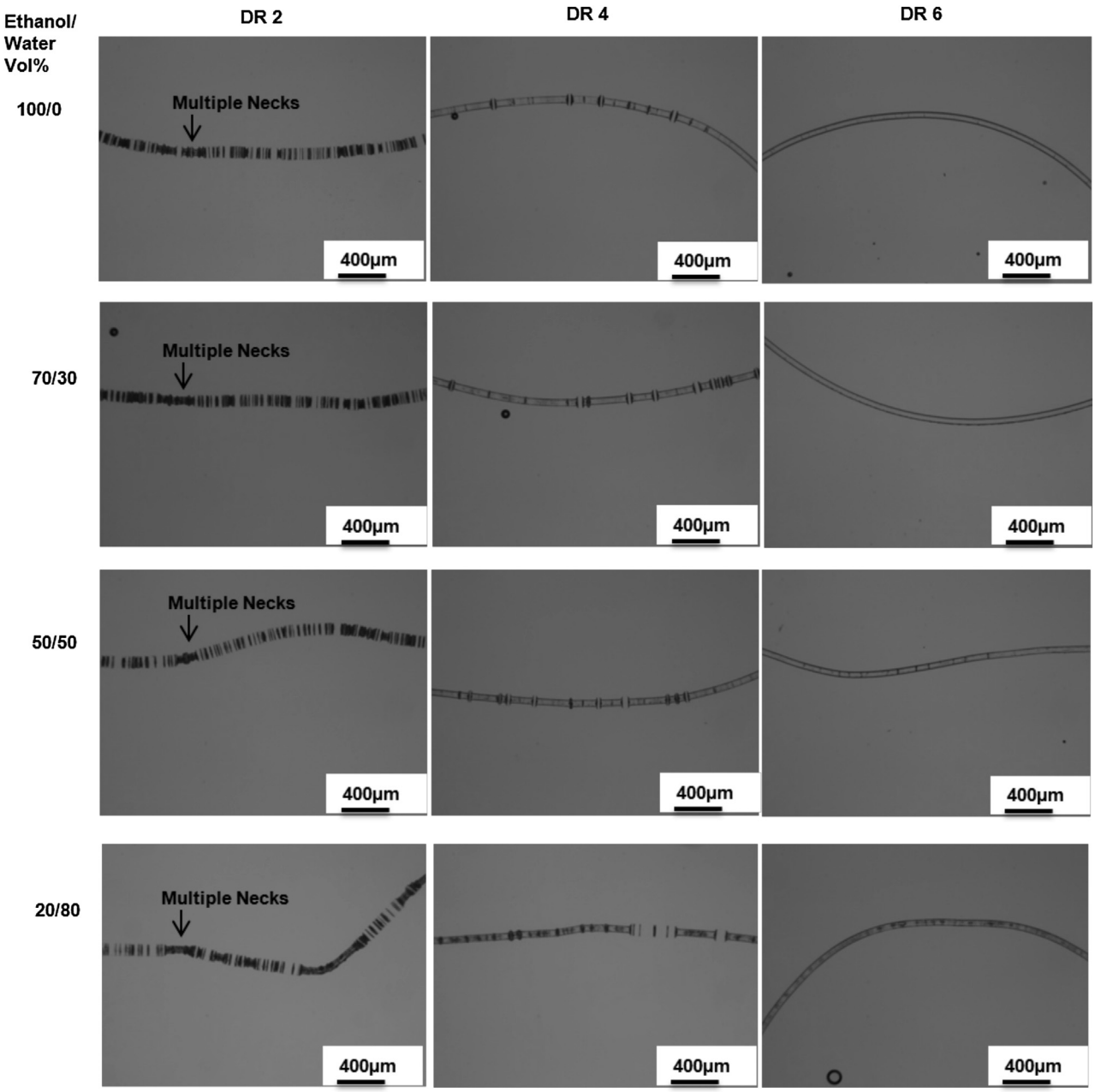

Fig. 2. Optical micrographs of PET filaments drawn to the nominal draw ratios of DR 2, DR 4 and DR 6 in ethanol/water solutions of various ethanol concentrations.