A STUDY OF RHEOLOGY, MORPHOLOGY, PROPERTIES AND MOLECULAR ORIENTATION OF THERMOTROPIC LIQUID CRYSTALLINE POLYMER/POLYPROPYLENE IN-SITU COMPOSITE FILM

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A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHYSICAL CHEMISTRY) FACULTY OF GRADUATE STUDIES MAHIDOL UNIVERSITY 2003

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ABSTRACT

Polypropylene (PP) was melt blended with a thermotropic liquid crystalline polymer (TLCP) (a copolyester of 80/20 mole ratio of \( p \)-hydroxy benzoic acid (HBA) and polyethylene terephthalate (PET), in a twin screw extruder. The blend extrudates were fabricated as cast films using a mini-extruder. Rheology, morphology, thermal behaviour, tensile properties, and molecular orientation of the composites were investigated. Effect of addition of four styrenic based compatibilisers on the properties of the 10 wt% TLCP/PP film was also investigated.

Melt viscosities of all pure components and blends measured at 295°C using a plate-and-plate rheometer exhibited shear thinning. The viscosity ratio (dispersed phase to matrix phase) was found to be very low, i.e. in the range 0.03-0.07. The morphology of the composite extruded strands viewed under a scanning electron microscope showed small droplets and some deformed TLCP domains, while elongated TLCP fibres were formed in the in-situ composite films. The aspect ratio (length to width) of TLCP fibres in the composite films grew progressively with increasing TLCP content up to 15 wt%.

With addition of various compatibilisers, the best fibrillation of TLCP phase was achieved in the 10 wt% TLCP/PP composite film compatibilised with 3 wt% SEBS1652. Thermal properties studied by a differential scanning calorimetry revealed that PP crystallinity slightly increased with addition of TLCP.

Addition of compatibilisers showed no significant effect on the final crystallinity of PP, but the crystallisation rate was retarded.

Values of the Young's moduli in the machine direction (MD) of the 5, 10 and 15 wt% TLCP composite films were increased to about 30, 60 and 130 %, respectively, over that of the neat PP film. The most effective compatibilisers for improvements in both Young’s modulus and tensile strength of the 10 wt% TLCP film were 3 wt% SEBS1652 and 5 wt% MA-g-SEBS, which rendered the enhancement of MD moduli for about 40 and 27.5 %, respectively, over the uncompatibilized blend. Molecular orientation in the composite films was investigated using Wide-Angle X-ray Scattering technique. In this work, we have developed a novel separation technique based on the spherical harmonic functions for determination of the orientation parameter of each phase in the composites.

Orientation parameters of the dispersed phase in the films containing 5, 10 and 15 wt% TLCP were found to be 0.65, 0.75 and 0.76, respectively, while that of the PP matrix itself was less than 0.01. Addition of each compatibiliser into the composite film has almost no influence on the orientation of both phases. It was found that the length-weighted average fibre aspect ratio showed a linear correlation with MD modulus since the long fibres are more effective than the shorter ones in the mechanism of reinforcement. On the other hand, the orientation parameters of TLCP phase showed a linear correlation with the MD Young’s modulus only up to 10 wt% TLCP content. The experimental moduli of the composite films were about 23-47 % lower than the calculated moduli predicted by Tsai-Halpin equation, due to the weak interaction at the interface and the non-uniform values of fibre aspect ratio. However, when 3 wt% SEBS1652 or 5 wt% MA-g-SEBS compatibilisers was added to the 10 wt% TLCP/PP film, the experimental modulus was only about 10 or 18.5 %, respectively, lower than that of the calculated values. This suggested that adhesion at the interfaces could be improved with addition of an appropriate amount of a suitable compatibiliser.

KEY WORDS : MOLECULAR ORIENTATION/ POLYPROPYLENE/ TLCP/ IN-SITU COMPOSITE/ FILM/TENSILE PROPERTIES

235 P. ISBN 974-04-2822-3
เรียนให้เรียนได้ที่ออกมีผลต่อโครงสร้าง และการจัดเรียงในอิน-ซิคลพอลิพีลีน (A STUDY OF RHEOLOGY, MORPHOLOGY, PROPERTIES AND MOLECULAR ORIENTATION OF THERMOTROPIC LIQUID CRYSTALLINE POLYMER/POLYPROPYLENE IN-SITU COMPOSITE FILM)

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บทคัดย่อ

งานวิจัยนี้เป็นการศึกษาผลผลิตและสัมประสิทธิ์ของคอมโพสิตพอลิเปปไทด์ (PP) แบบแป๊กบริคก์ (TLCPP) ซึ่งเป็นพอลิเปปไทด์ของพอลิเปปไทด์ (PET) ได้ไขว้รวมและต่อเชื่อมกันได้กับพอลิเปปไทด์clasส์ (HBA) หรือพอลิเปปไทด์คลาสส์ (PET) ได้ไขว้รวมและต่อเชื่อมกันได้กับพอลิเปปไทด์ clasส์ (HBA) หรือพอลิเปปไทด์คลาสส์ (PET) ได้ไขว้รวมและต่อเชื่อมกันได้กับพอลิเปปไทด์ clasส์ (HBA) หรือพอลิเปปไทด์คลาสส์ (PET) ได้ไขว้รวมและต่อเชื่อมกันได้กับพอลิเปปไทด์ clasส์ (HBA) หรือพอลิเปปไทด์คลาสส์ (PET) ได้ไขว้รวมและต่อเชื่อมกันได้กับพRALPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPEPE