Egypt. J. Chem. **Vol. 63,** No. 3, pp. 1055-1061 (2020)

Egyptian Journal of Chemistry
http://ejchem.journals.ekb.eg/

Correlation between Parameters of Extrusion Technique and Both of Optical and Physical Characteristics of Reinforced Polypropylene Composites

Hind M. Saleh
Department of Chemistry, College of Science, University of Misan, Misan, Iraq.

THIS RESEARCH was an attempt to illustrate the correlation between parameters of extrusion technique (screw speed) which was used to produce conventional and hybrid reinforced polypropylene composites and their optical and physical characteristics. The obtained results demonstrated the responses of hybrid reinforced composites were more stable and higher than those of conventional reinforced composites. Furthermore; the density and optical traits of hybrid composites were influenced extremely by the screw speed variation (reduction). The syndiotactic polypropylene was used as a matrix while talc and graphite were used as reinforcing agents (fillers) to prepare diverse weight percentages of reinforced polypropylene composites.

Keywords: Agent, Fluctuation, Hybrid, Impact, Matrix, Response, Weight percentages.

Introduction

With the present rapid advance in much industrial application, it is very clear that polymers have played a vital role in diverse industries. There is a wide spectrum of polymers that can be categorized to natural such as amber, silk, shellac and artificial such as phenol-formaldehyde, neoprene, nylon [1-4]. Polypropylene is one of indispensable artificial polymer in different fields due to it is exclusive properties, for example, it is used in packaging industry because of its excellent obstruction and large withstanding, whereas in electricity sector it is considered a key element in manufacturing of diverse components including resistors, capacitors, inductors as well as cables of transmission system due to its huge insulation which provides a high safety and reliability to small and large scale electrical applications. Furthermore, polypropylene has important quality of waterproof that`s why it is used in the marine industry [5]. The high confrontation of Polypropylene against dangerous microorganisms such as bacteria and it`s distinct opposition against chemical oxidization made it so crucial module in medical industries, for instance, manufacturing of syringes, pill containers, and sample tubes. It is worthy to mentioning polypropylene has been utilized for medical treatment purpose, surgery operations which deal with the unusual outlet of an organ, for instance in bowel surgery, miniature piece of the Polypropylenes put over the pimple of the unusual outlet, underneath the skin [6]. The physical characteristics of polypropylene such as density rely on molecular weight distribution as well as the reliability of the macromolecular configuration controls the amount of its stiffness. The improvement techniques of polypropylene characteristics have paved away to extreme progress in practical and scientific fields, the reinforcement is one of the outstanding approaches to accomplish imperative adjustments on features of different composites of polypropylene. A composite polypropylene is commonly made of reinforcement substances inserted in a matrix (polypropylene). These substances (agents) can be fibers such as flax, hemp, and jute or minerals such as talc, calcium carbonate, and graphite. The matrix is responsible

Corresponding author e-mail: hind1980@uomisan.edu.iq
Received 21/12/2019; Accepted 19/1/2020
DOI: 10.21608/ejchem.2020.21244.2269

for clutching the reinforcement whereas the reinforcement filler (agent) advances the whole properties of the matrix. Talc, mica, and graphite are at the top of most common agents that amend optical and physical behaviors of polypropylene [7, 8]. Talc is one of the most useful minerals, it can exist as a powder or solid, it is easily grazed colorful material, it might be gray, brown, and white. The density of talc is within 2.7-2.8 g/cm^3 , melting temperature is 800C^0 and normally it does not dissolve in water. Wide range applications of talc including paper manufacture, plastic, coating techniques, rubber, food, pharmaceuticals, beauty industries [9]. Another fundamental reinforcement agent is graphite; it is a natural powder form of carbon. It is exceptionally malleable; it can be separated with low pressure. The density of graphite is within 2.09-2.33g/cm^3, melting temperature is about 1649C^0, normally it does not dissolve in water. It is enormously opposing to heat, such remarkable properties qualified it to use in diverse industrial applications for instance polishes, paints, and manufacturing of steel[10]. The proposed research concentrated on talc and graphite as most important conventional reinforcement agents, in addition to hybrid proposed agents constructed by talc and graphite combination, unlike many types of research the proposed study used extrusion technique to produce study composites of reinforced polypropylene; conventional(syndiotactic polypropylene + talc), (syndiotactic polypropylene + graphite) and hybrid (syndiotactic polypropylene + talc + graphite). Some of the optical and physical characteristics of proposed composites were discussed involving weight percentages of compositions as well as the impact of screw speed on alteration.

Work environment of study

Basically three main methods are used to produce reinforced polypropylene composites (polypropylene + agents), these methods are injection molding, compression molding, and extrusion method. The injection molding technique generally depends on injecting (inserting) raw material into a particular mold in order to get the required shape of the product, for example, sheet or pipe. The mechanism of this method can be summarized in three steps, first is melting raw polypropylene and agent by heat then the molten material will be subjected to the cooling system and finally coagulating the merging composite via molds for getting final shapes. The injection molding is a perfect choice for soaring size and low-cost constituent industrialized [11]. One of the most common and conventional methods to prepare reinforced polypropylene is compression molding. The raw material will be subjected to a tremendous amount of force so as to contact molds at the same time as heat and pressure are sustained awaiting the forming material has treated. The main benefit of this method is its facilitating production huge number of components with diminutive deviations in dimensions. The diverse forms and convolution have been accomplished by compression molding. This technique has a high cost of equipment but affordable for low quantity production [12]. The extrusion process includes a series of operations, they start with transforming a raw polypropylene from solid to a liquid by heating then merging with the reinforcement agent and screw will move forward the combination (polypropylene+ agent) throughout heated canister. A die has performed the most important task to assign a constant cross-sectional area to a flow of liquid combination (composite) so as to shape the composite in the required forms for instance rods, films and sheets [13, 14].

Materials and Method

The excellent and inimitable properties of syndiotactic polypropylene due to its exclusive crystallization performance as well as many researchers have concentrated on normal commercial isotactic polypropylene, the two mentioned factors encouraged the proposed study to take advantage and rely on syndiotactic polypropylene as a major material to accomplish current research [15-18]. The characteristics of raw syndiotactic polypropylene which was used in the present study can be summarized in Table 1.

TABLE 1. Characteristics of raw syndiotactic polypropylene.

Melting temperature	145C^0
Density	0.855 g/cm^3
Yield stress	35 MPa
Elongation at yield	9–11%
Young’s modulus	0.93 – 1.18 Gpa

It is worthy of mentioning that the reinforcement agents which were used in the suggested study selected with properties close to those mentioned previously. In order to examine the optical characteristics of the proposed composites, the UV300/2FD-V3 spectrophotometer (Shanghai Insmark Instrument Technology Co., Ltd.) was used to perform this task. Induction heating furnace with 3000C^0 was utilized so as to overcome the mismatching in the temperature of melting between matrix and fillers. So, this step facilitated the extrusion process extremely. The extrusion process has been achieved by a mini twin-screw extruder (manufacturer: Jieya, model: SHJ-30, diameter: 30mm, L/D: 32-68, motor power: 11KW, screw rpm: 400-600).

Proposed method

The proposed research depended on extrusion technique to prepare study samples of reinforced polypropylene composites with various weight percentages of matrix and agent; conventional samples of are in forced composites are (syndiotactic polypropylene + talc), (syndiotactic polypropylene + graphite)and hybrid reinforced composites(syndiotactic polypropylene + talc + graphite) used to study density and optical characteristics. The weight percentages ratios of both talc and graphite composites samples (syndiotactic polypropylene + talc or graphite) were (95+5, 90+10,85+15 %) whereas ratios of hybrid composites(syndiotactic polypropylene + talc + graphite) were (95+2.5+2.5, 90+5+5, 85+7.5+7.5 %). The abbreviations of study samples were SPPT (syndiotactic polypropylene + talc), SPPG (syndiotactic polypropylene + graphite) and SPPGT(syndiotactic polypropylene + talc + graphite). The extruder machine with mentioned features started the process with normal conditions (room temperature, screw speed was 550rpm) all results for each composite features were measured with diverse weight ratios. The significant task in the proposed study was using a speed controller to vary the screw speed, the measured results were not varied significantly for a wide range of speed variation but at 125 rpm remarkable changes in physical and optical responses for hybrid composite were measured.

Results and Discussion

Physical (density) response

Figure 1 has illustrated clearly that the density of different composites increased consistently with the increase of weight percentages of added agents. So, the density of SPPG (syndiotactic polypropylene + graphite) is varied from 0.948gm/cc to 0.973gm/cc up to 1.07 gm/cc whereas the density of SPPT (syndiotactic polypropylene + talc) is varied from 0.964gm/cc to 1.012gm/cc up to 1.19gm/cc. The response of SPPGT (syndiotactic polypropylene + talc + graphite) start from 0.927gm/cc to 1.032gm/cc up to 1.35gm/cc. All of these results are measured at a screw speed of 550 rpm. The response of SPPGT is higher than the other two composites.

Figure 2 has shown the density responses for each composite after reducing the screw speed to 125rpm by the speed controller. In general, there are no differences in terms of density responses for SPPG and SPPT composites while for SPPGT significant alterations in its physical behavior are demonstrated. The density responses of SPPGT witness sharp fluctuations then consistent increase before a considerable stop in response at 1.065gm/cc that signifies obviously the structure of proposed hybrid composite is undergoing saturation with the increase of the weight percentage of talc and graphite.

Optical response

The optical responses of SPPG composite samples are shown in the Figure 3, the response of SPPG-5% undergoes sharp fluctuations within the range of wavelength (200-400 nm) then the absorption of spectrum starts gradually to decrease to a wavelength of 700nm. Finally, the optical response is more stable and there are no observable changes. While the optical characteristic of SPPG-10% diverges from 200nm to 600 nm then begins to be more steady clearly. The remarkable advance in the absorption of the spectrum is achieved with SPPG-15%, there are no sharp changes or ripples in the optical response, so this sample is more steady optically than the other two composites.

Figure 4 shows the optical traits of SPPT composite samples, the response of SPPT-5% goes down within a range of wavelength (200-700 nm) then the absorption of the spectrum starts to be more unwavering. Whereas the optical characteristic of SPPT-10% is fluctuated slightly then diverged within the same mentioned range of wavelength and it commences to be more steady evidently. There is a noticeable matching in the optical responses for both SPPT-5% and SPPT-10 % samples from the wavelength of 550nm onwards. Like SPPG-15%, the absorbance of the spectrum of SPPT-15% is more steady with wide wavelength at higher rate of absorbance spectrum.

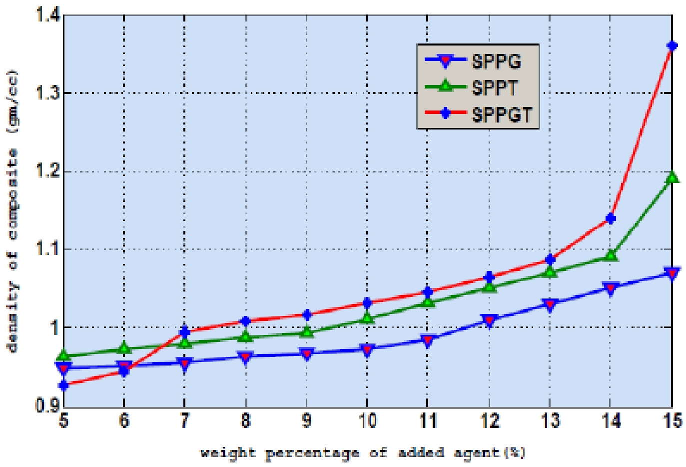

Fig.1. Impact of added agent on composite density at 550 rpm.

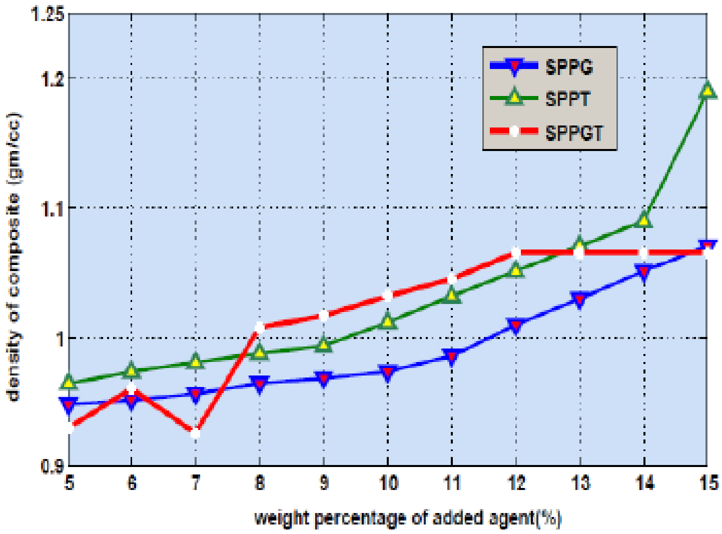

Fig. 2. Impact of added agent on composite density at 125 rpm.

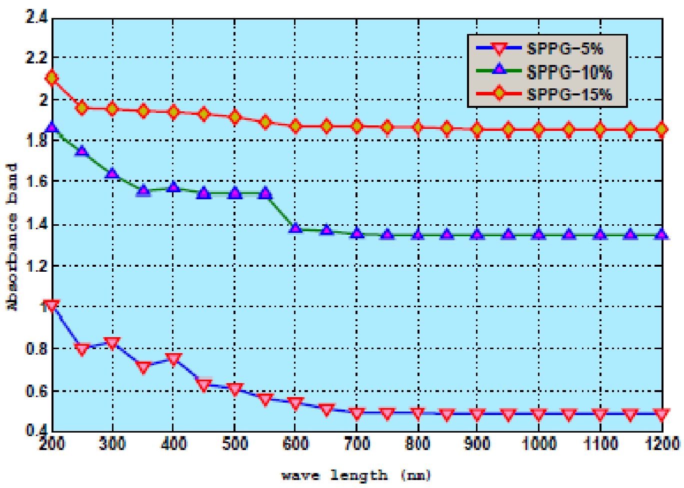

Fig. 3. Optical responses of SPPG composite samples at 550 rpm.

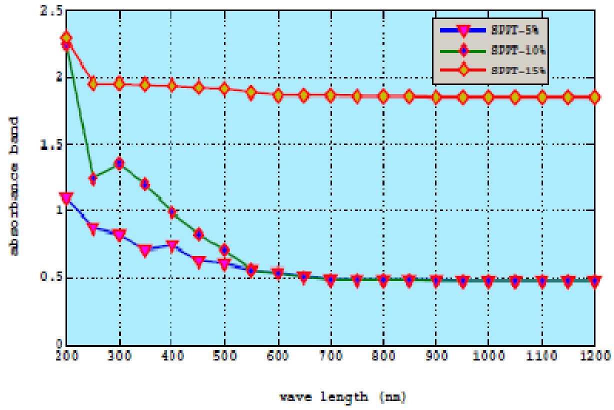

Fig. 4. Optical responses of SPPT composite samples at 550 rpm.

The optical attributes of SPPGT composite samples are explained in the Figure 5, an extreme convergence is illustrated in the optical responses of SPPGT composite samples and those of SPPT shown in Fig. 4. There are few slight fluctuations for SPPGT-5% and SPPGT-10% within a short range of wavelength except that the optical characteristics of SPPGT meet traits of SPPT obviously. The screw speed is reduced from 550 rpm to 125 rpm via speed controller. On the whole, noticeable deviations have not appeared in terms of absorbance spectrum for SPPG and SPPT composites while for SPPGT composites important amendments in optical features are demonstrated. The responses of SPPGT start with spiky fluctuations for all weight of percentages then the optical traits stabilize at low levels for all weights and absorbance response of SPPGT -15% is higher than the other two samples. Figure 6 shows obviously the impact of speed reduction on optical characteristics of hybrid composites.

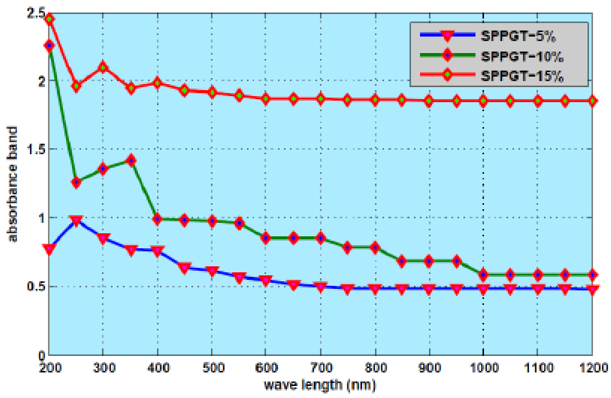

Fig. 5. Optical responses of SPPGT composite samples at 550 rpm.

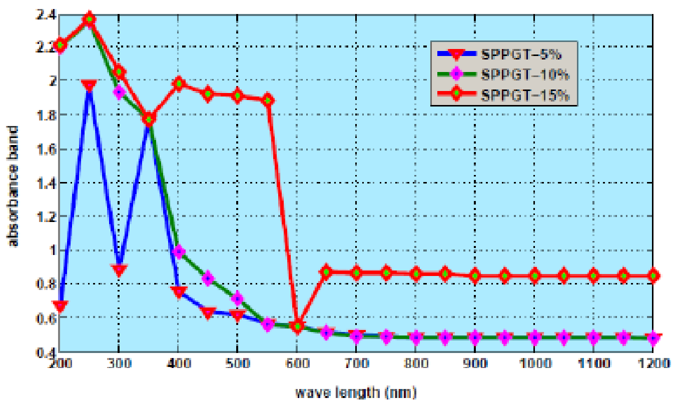

Fig. 6. Optical responses of SPPGT composite samples at 125 rpm.

Conclusions

Under normal working screw speed, the density and optical responses for conventional (talc and graphite) and hybrid composites of reinforced polypropylene increased consistently with the increase of weight percentages of reinforcement agents. The characteristics of conventional composites were not affected by the remarkable reduction in the screw speed, on the other hand, traits of hybrid composites were influenced considerably. In other words, there was an obvious correlation between the features of hybrid composites and extrusion technique parameters consequently, the density and optical characteristics can be a function of working speed and controlled by it as well as the function of weight percentages of added agents from the chemical view. The impact of screw speed variation was higher than that of weight percentages of added agents on the density and optical features of hybrid composite, Figure 2 and Figure 6 showed clearly that. Generally, the physical and optical responses of hybrid composites were higher and stable more than conventional composite responses, which means the progress in hybridization techniques will contribute extremely to the improvement of composites traits.

References

1. Batten, S. R., Neville, Suzanne M., Turner, D. R. "*Coordination Polymers: Design, Analysis and Application*". Royal Society of Chemistry (2008).
2. Driss, R., Touria, J. and Abdelkrim, Ch. Spectroscopic and thermal degradation studies of novel hybrid polymer based on sodium polyphosphate-polystyrene. *Mediterranean Journal of Chemistry*, **7**(5), 337-345 (2018).
3. Tamilselvi, D., Velmani, N., Rathidevi, K. Electrical conductivity studies of zinc oxide, nickel doped zinc oxide poly (o-toluidine) nanocomposite using chemical oxidative polymerization. *Egyptian Journal of Chemistry,* **63**(Special Issue, Part 2) (2020).
4. Abou-Yousef, H., Kamel, S., Gad, N. Utilization of short-cut PET fibers as reinforcement additive for kraft bagasse paper making. *Egyptian Journal of Chemistry*, **60**(4), 653-665 (2017).
5. Vaidyanathan, R., Chiel, H. J., Quinn, R. D. A hydrostatic robot for marine applications. *Robotics and Autonomous Systems*, **30**(1-2), 103-113 (2000).
6. Balcı, M., Allı, A., Hazer, B., Güven, O., Cavicchi, K., Cakmak, M. Synthesis and characterization of novel comb-type amphiphilic graft copolymers containing polypropylene and polyethylene glycol. *Polymer Bulletin*, **64**(7), 691-705 (2010).
7. Stokke, D. D., Gardner, D. J. Fundamental aspects of wood as a component of thermoplastic composites. *Journal of Vinyl and Additive Technology*, **9**(2), 96-104 (2003).
8. Bledzki, A. K., Faruk, O. Microcellular injection molded wood fiber-PP composites: part I- effect of chemical foaming agent content on cell morphology and physico-mechanical properties. *Journal of Cellular Plastics*, **42**(1) 63-76 (2006).
9. Premalal, H. G. B., Ismail, H., Baharin, A. Comparison of the mechanical properties of rice husk powder filled polypropylene composites with talc filled polypropylene composites. *Polymer Testing*, **21**(7), 833-839 (2002).
10. Pierson, H. O. "*Handbook of Carbon, Graphite, Diamonds and Fullerenes: Processing, Properties and Applications*". William Andrew (2012).
11. Panthapulakkal, S., Sain, M. Injection-molded short hemp fiber/glass fiber-reinforced polypropylene hybrid composites—Mechanical, water absorption and thermal properties. *Journal of Applied Polymer Science*, **103**(4), 2432-2441 (2007).
12. Shubhra, Q. T., Saha, M., Alam, A. K. M. M., Beg, M. D. H., Khan, M. A. Effect of matrix modification by natural rubber on the performance of silk-reinforced polypropylene composites. *Journal of Reinforced Plastics and Composites*, **29**(22), 3338-3344 (2010).
13. Shubhra, Q. TH., Alam, A. K. M. M., Quaiyyum, M. A. Mechanical properties of polypropylene composites: A review. *Journal of Thermoplastic Composite Materials*, **26**(3), 362-391 (2013).
14. Fu, S. Y., Lauke, B., Mäder, E., Yue, C. Y., Hu, X. Tensile properties of short-glass-fiber-and short-carbon-fiber-reinforced polypropylene composites. *Composites Part A: Applied Science and Manufacturing*, **31**(10), 1117-1125 (2000).
15. De Rosa, C., Auriemma, F. Structure and physical properties of syndiotactic polypropylene: a highly crystalline thermoplastic elastomer. *Progress in Polymer Science*, **31**(2), 145-237 (2006).
16. Auriemma, F., De Rosa, C., Malafronte, A., Scoti, M., Di Girolamo, R. Solid State Polymorphism of Isotactic and Syndiotactic Polypropylene. In:

"*Polypropylene Handbook*", pp. 37-119. Springer, Cham (2019).

17. De Rosa, C., Scoti, M., Auriemma, F. Crystallization behavior, morphology and mechanical properties of copolymers of syndiotactic polypropylene with branched monomers. *APS Meeting Abstracts* (2019).

18. Endo, F., Kurokawa, N., Tanimoto, K., Iwase, H., Maeda, T., Hotta, A. SANS study on the nano-crystalline network structure of elastic physical gels made of syndiotactic polypropylene. *Soft Matter*, **15**(27), 5521-5528 (2019).