Middle East Technical University

Department of Metallurgical and Material Engineering

Mete215 – Materials Processing Laboratory

Experiment 4: Production of Polymer / Short Fiber Composites

Instructor: Prof. Dr. Cevdet KAYNAK

Assistant: D. Doğanay

Experiment Date: 7.11.2019

Submission Date: 18.11.2019

Name: Doruk Sınayuç

No: 2379808

Group Members: Murathan Cugunlular, İklim Ozturk, Melisa Yildirim, Ezgi Eylen, Mehmet Oguz Yavuz, Darin Azzam Ahed Alaryan, Bahattin Emre Boran, Ekin Kursun, Arslan Korcan Ozal, Olgu Cagan Ozonuk, Bahadir Akman, Onur Das

Abstract

Polymers are materials that are lightweight but have low mechanical properties. In this experiment the differences of short fiber reinforced polypropylene and pure polypropylene were observed. This was done by using 10 grams of only polypropylene and using the twin-screw extruder to get the polymer and 1.5 grams of short fiber glass and 8.5 gram of polypropylene to get the composite using the twin-screw extruder again. The volume percent for the second procedure was 94% for polypropylene. It was observed that the composite had more strength, less transparency and a shinier look compared to the polymer.

Introduction

Polymers can be considered as an important and main category of materials like metals and ceramics. They are used in variety of places such as biomaterials, in 3D printing, in coatings, in structural adhesives and composites, blootproof and fire-resistant as well as waterproof fabrics and many more (Elsevier, 2019). Polymers are made out of small parts named monomers. When these monomers bond they form a chain and create the polymers. This monomer is very important as it will affect the properties of the polymer that it will create.

The Polymers in general, unlike that of metals and ceramics has less mechanical properties but it is much more lightweight. This lightweight characteristic of the polymers makes them a valuable material that is being used in variety of places that has been mentioned above. However, sometimes the mechanical or other properties of the polymer is needed and desired to be improved. To do this polymers are compounded with other materials (Kaynak, 2019). By compounding the polymers are mixed with additives and fillers such as “curatives, reinforcements, anti-degradants, process aids and specialty additives” (E.K.Silviya, 2009). This way the properties of the resulting polymer after the compounding can be increased. Therefore, it can be said that a composite polymer that is lightweight having relatively good mechanical, and thermal properties can be created.

Composites are the result of two materials being mixed together to create a new material that has the best properties of the materials that it is composed of. This is generally done by inserting reinforcements like fibers and particles inside the matrix of the three main material categories which are metals, polymers and ceramics (Dragan Aleksendrić, 2015). Generally this results in the composites having high strength less weight and better environment resistance (Dragan Aleksendrić, 2015). The polymers after being mixed with additives and fillers are also a form of composites. This is parallel to the definition of composites as the lightweight polymers with low mechanical properties can be evolved into a composite with still lightweightness but better mechanical and other properties.

Therefore, the reasons of polymer compounding and composite making can be basically summarized by the following two points;

- Better properties than that of the materials that makes the composite
- With better properties the variety of places that the material can be used increases

Experimental

Materials that were used;

- Polypropylene (18.5 gram → 10 gram first sample, 8.5 gram second sample)
- Short Glass Fibers (1.5 gram → 1.5 gram second sample)

Equipment that were used in the experiment;

- Laboratory size Twin-Screw Extruder
- Precision Balance
- Pelletizing machine

Procedure

To begin the experiment, the twin-screw extruder was arranged to heat to the desired temperature. While the extruder was heating, polypropylene (PP) and short glass fibers were weighed in the precision balance weighing machine to create two samples to be used in the experiment. After that the materials were ready and the twin-screw extruder was in the desired temperature. Firstly, the first sample which consisted of only polypropylene was added to the extruder. 50 rpm was set for the machine as it is the ideal value for PP. The lab assistant picked a student to wear heat gloves and get the PP coming out of the machine. After all of it was gotten it was of a considerable length therefore the pelletizer machine was used to shorten it. Then, the second sample consisting of both PP and short glass fiber (SGF) was put into the machine at the same rpm. The same student wearing the heat gloves also help get the composite coming out of the machine and pelletizer was once again used to shorten it.

Figure 1. Student getting the PP from the twin-screw extruder

Basic Steps in Melt Mixing by using Twin-Screw Extruder

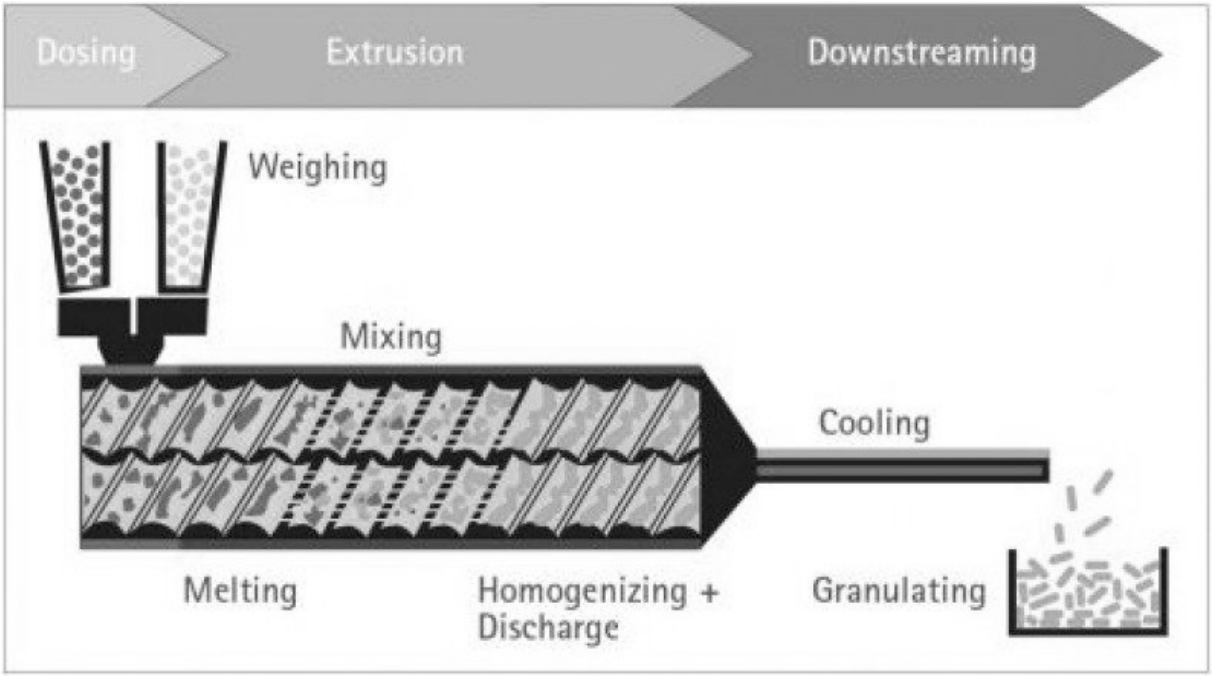

Figure 2. The twin-screw extruder process (Chinna Reddy Palem, 2011)**.**

In figure 2 the schematic representation of the twin-screw extruder process can be seen. To summarize the process, first the material is conveyed into the machine where it starts to melt. After it is in the molten state it begins to mix and after it is mixed and homogenized it gets pumped out of the machine.

RESULTS AND DISCUSSION

These are the points that are going to be discussed in this part;

1. Effects of temperature in the process
2. Effects of the SGF added to PP
3. Comparison of PP and the SGF-PP composite
4. Why the pelletizer was used
5. Effect of rotation speed
6. Calculations of volume percent of matrix and reinforcement material.

But before starting on discussing about these points let's look and discuss on the observations made during the experiment.

The first thing to note is that when the first sample came out of the machine it was of the color yellow which is not expected. The reason for this is that the yellow color was the result of what was left in the machine from the experiment done before this. As time passed the color turned to the expected white color. The second thing to note is that the second sample consisting of SGF and PP is less transparent compared to the first sample. This is because of SGF scattering the light. The SGF also causes the second sample having a relatively shiny appearance.

To touch upon the points mentioned above;

1) Temperature is an important parameter for this experiment. The temperature used should be such that the polymers melt but not high enough for them to degrade. The twin-screw extruder has 5 zones with one of them being the die. The temperature profile for them is:

Zone 1	Zone 2	Zone 3	Zone 4	Die
165 ^{0}C	210 ^{0}C	220 ^{0}C	220 ^{0}C	200 ^{0}C

Table 1. Temperature profile of twin-screw extruder (Kaynak, 2019).

These are the temperatures used in the respective zones. The data gotten from the lab handout. By using lower temperature, the polymer may not melt and by using higher temperatures there is a risk of the polymer degrading.

2) The SGF added to PP is a composite where PP acts as the matrix and the SGF as the reinforcement. They can be categorized under Short-fiber reinforced polymer (SFRP). Generally, with higher amount of fibers being used the strength and modulus of the composite increases (S. Y. Fu, 2000). Meaning that with the addition of SGF to PP the strength as well as the modulus increase. This was indeed the case in the experiment as the strength of the second sample was more than that of the first sample.

3) Some of the observations were mentioned above but to touch upon them here it can be said that with the addition of SGF to PP the transparency decreased and it became relatively more rigid. It also became shinier due to SGF scattering the light. The composite is also stronger than that of the polymer and the density of the composite is higher of the polymer. This makes it weightier.

4) The reason that the pelletizer was used is because the polymer or composite coming out of the twin-screw extruder machine is considerably long which is not something that is wanted for injection molding. Therefore, to shorten it the pelletizer machine is used.

5) The effect of the rotation speed is also an important parameter in the experiment. In the experiment the value of 50 rpm was used. This was considered to be the ideal value in the case of PP. Ideal is said to be when the polymer or the composites goes through the extruder in a way such that it is not too fast as it may not melt and mix as desired or too slow where it may degrade. The reason that the good mixing and melting is wanted is because if that is not the case it will result in defects in the material decreasing the strength and durability of the material which defeats the purpose of making composites.

6) The density of Glass fiber and polypropylene is 0.903 (g/cm^3) for polypropylene and 2.55 (g/cm^3) for glass fiber (S. Y. Fu, 2000).

Properties	Mass (gram)	Density (g/cm^3)	Volume (cm^3)
Polypropylene	8.5	0.903	9.4
Glass Fiber	1.5	2.550	0.6

Table 2. The properties of the materials used in sample 2

In table 2 the mass and density of the materials that makes up the sample 2 can be seen. The volume was calculated from the equation V=m/d where; V= volume, m= mass, d= density.

Volume of Polypropylene: 8.5(gram) / 0.903(g/cm^3) = 9.4 cm^3

Volume of Polypropylene: 1.5(gram) / 2.550(g/cm^3) = 0.6 cm^3

From this data it is possible to calculate the volume percent of SGF and PP. It can be done with the equation; $(V_1/V_1+V_2)*100$. Therefore,

Volume percentage of PP is: $(9.4cm^3/9.4cm^3 + 0.6cm^3)*100 = 94\%$

Volume percentage of SGF is: $(0.6cm^3/9.4cm^3 + 0.6cm^3)*100= 6\%$

Similarly the mass percentage can be found with the equation; $(m_1/m_1+m_2)*100$. Therefore,

Mass percentage of PP is: (8.5gram/8.5gram + 1.5gram)*100 = 85%

Mass percentage of SGF is: (1.5gram/8.5gram + 1.5gram)*100 = 15%

Conclusion

In this experiment, the differences between pure polypropylene and short glass fiber reinforced polypropylene were observed. To summarize it can be said that the composite was shinier, less transparent and had more mechanical strength than that of the polymer. This shows the importance of the composites as by mixing two different materials another material with better properties was produced. This can become more important in the case of polymers as polymers are materials with less weight but also low mechanical properties. But as seen by the experiment they can be reinforced which makes them a very important material. This can be seen by the variety of places that the short glass fiber reinforced polypropylene can be used. Namely, Automotive industry, appliance industry, communications, electronics, and electrical appliances industries and many more. (LFT-G, 2018). These usage areas are also true for other short fiber reinforced polymers.

References

Chinna Reddy Palem, K. C. (2011). A Review on Bioadhesive Buccal Drug Delivery Ssystems: Current Status of Formulation and Evaluation Methods. *Journal of Faculty of pharmacy* , 385-403.

Dragan Aleksendrić, P. C. (2015). *Soft Computing in the Design and Manufacturing of Composite Materials.* Woodhead Publishing.

E.K.Silviya, S. G. (2009). *Advances in Polymer Processing.* Woodhead Publishing.

Elsevier. (2019). *Computational Quantum Chemistry.* Amsterdam: Elsevier.

Kaynak, C. (2019). Production of Polymer / Short Fiber Composites. *Lab Handout*.

LFT-G. (2018, June 15). Retrieved from LFT-G: https://www.lfrt-plastic.com/news/why-ford-uses-long-glass-fiber-reinforced-pp-r-15251900.html

S. Y. Fu, B. L. (2000). Tensile properties of short-glass-fiber- and short-carbon-fiber-reinforcedpolypropylene composites. *Composites: Part A*, 1117-1125.