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Research Paper

Recycled material made from sludge of paperboard making process

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ABSTRACT

This research was conducted to obtain a recycle material from sludge wasted during paperboard making process. The waste sludge was mixed and extruded with LDPE plastic. A coupling agent, polyethylene-graft-maleic anhydride (PE-g-MA) coupling agent, was used to improve the properties of the plastic composites. Factors affecting plastic composite properties were investigated including % sludge loading at 1, 3 and 5% by total weight and %PE-g-MA loading at 3 and 5% by total weight. The materials were first pelletized using a twin-screw extruder and then processed by injection molding. The mechanical and physical properties of the samples were examined. It was found that the mechanical properties of LDPE/sludge plastic were changed when the sludge was added. It was also shown that sludge loading decreased tensile strength and impact strength of composite plastic insignificantly. In contrast, other physical property of composite plastic, elasticity and elongation at break was increased when the % of sludge loading was increased.

Key words: Sludge, recycle, paperboard.

INTRODUCTION

Currently, Thai Cardboard Company delete sludge by landfill due to the problem of daily 1-5 tons of sludge produced from white – grey cardboard making process. However, before landfill, the sludge had been checked for its toxic residue and it had passed the minimum threshold from the department of Pollution control. Therefore, the company has initiated its staff to try to determine the advantage of this sludge.

Plastic consumption has been increased significantly in the past couple of decades since it has better properties that are advantageous than other materials such as metal and glass. As a result of the increasingly use of plastic, the disposal of used plastic has already become a major environmental concern since plastic is very difficult to degrade by itself or it takes very long period to degrade. Besides, if it is terminated by burning, some kinds of plastic will release toxic gas when they are burnt (Ornusa, 2003). Therefore, recycling of used plastic is one of the interesting methods widely used to discard plastic since it does not cause any harm to the environment.

Polyethylene (PE) is a widely used polymer in both film and plastic containers since it is inexpensive, good performance and recyclable. Polyethylene is less durable than other types of plastic. There are various methods to improve the strength of PE such as by adding fiber to increase its toughness and strength. Eventually, this material is also called "composite plastic"(Sornnil, 2004). Composite materials have been known for many years. At present, composite material is been used in various industries such as automotive industry, construction industries and furniture (Tandon, and Wang, 1988).

They are known as inexpensive and reusable material but with lower mechanical properties than pure plastic. Due to the difference in polarity between PE polymer and natural material, they cannot be well mixed together (DeArmitt, and Rothon, 2017). Therefore, coupling agent is added in order to improve the compatibility of all raw materials in composite plastic (Faruk and Matuana, 2008; Yeh and Gupta, 2008; de la Orden et al., 2010; Yang and Qin, 2001). This study was conducted to examine the formation of composite material from low density polyethylene (LDPE) and sludge, and to determine the appropriate amount of

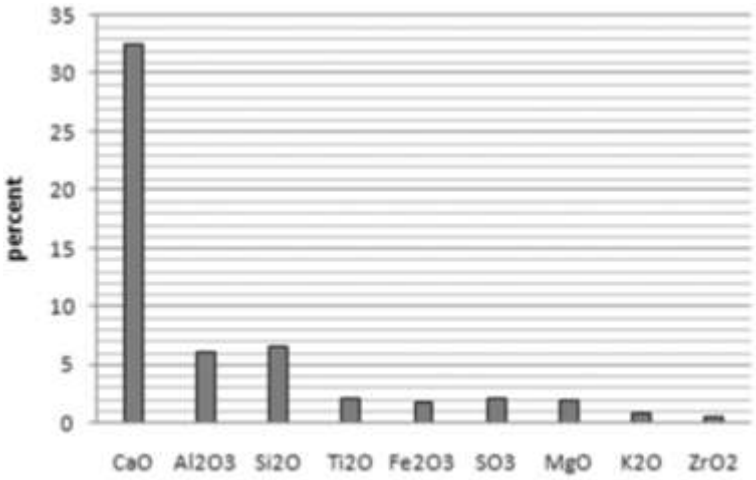

Figure 1: Percentage of chemical compounds in sludge.

both sludge and LDPE for such composite plastic. Furthermore, the research also intended to find proper coupling agent required to be added to the composite plastic, as well as to examine the mechanical and physical properties of the prepared composite plastic.

MATERIALS AND METHODS

Preparation of sludge with surfactant solution

100 g of wet sludge was mixed with anionic surfactant at 1% concentration by weight (Sodium Dodecyl Benzene Sulfonate). Then the sludge was spun with surfactant for 10 min in order to wash the sludge. All surfactants were cleaned up from the sludge using distilled water and the pH was continuously measured during the cleaning until its pH was in the range of 6-7. The cleaned sludge was filtered with a filter paper No.91 and the sludge was dried in an oven at 100°C for 1 h or until its weight was constant.

Preparation of composite plastic and sample testing

In this experiment, virgin polyethylene (LDPE,MFI 6 g/10 min) and Recycled LDPE (MFI 0.309g/10 min) from May Enterprise Co.,Ltd were used. LDPE was mixed with prepared sludge in different percentages such as 1, 3 and 5% by total weight. A maleic anhydride coupling agent (Wypych, 2018) (Licimont AR 504) from Clariant Chemicals (Thailand) Co.,Ltd was added to the prepared composite plastic in different percentages such as 3 and 5% by total weight. In addition, antioxidant (HOSTANOXP-EPQP) from Clariant Chemicals (Thailand) Co., Ltd was added as 0.1% by weight in all prepared composite plastic. Then another set of composite samples were made with the same conditions and methods, but recycled LDPE was used instead of virgin LDPE. The different combination of preparing composite material was mix for compounding in a twin screw extruder (HAAKE Polylab Rheomex CTW 100 p) and then all compounds were injected (screw speed 170 cycle/min, screw diameter 22 mm and injection pressure 55 bars) to form standard dumbbell for testing according to ASTM D638.

The prepared composite samples in different composition were tested for their tensile strength and impact resistance according to ASTM D 638 and ASTM D256 using Izod impact, Gotech.

The chemical compounds of sludge were measured using X-ray fluorescence spectroscopy (XRF: PW2400, Phillips). Microstructures of sludge and composite plastic were observed using scanning electron microscope (SEM: S4800, Hitachi).

RESULTS AND DISCUSSION

Sludge preparation with surfactant

After the sludge was washed with anionic surfactant solution, it was evaluated by X-Ray Fluorescense Spectroscope (Figure 1). The result showed that anionic surfactant could wash out heavy metal such as alumina, silicon dioxide, titanium dioxide, and sulfur trioxide from sludge. Besides, it was found that CaO was the most left compound in the sludge after getting through the washing stage by anionic surfactant. Figure 2 shows a microstructure of sludge that comprised fine particles.

Mechanical properties of composite plastic

The sludge-LDPE composite plastic had green color related to %sludge contents, which the highest content of 3%

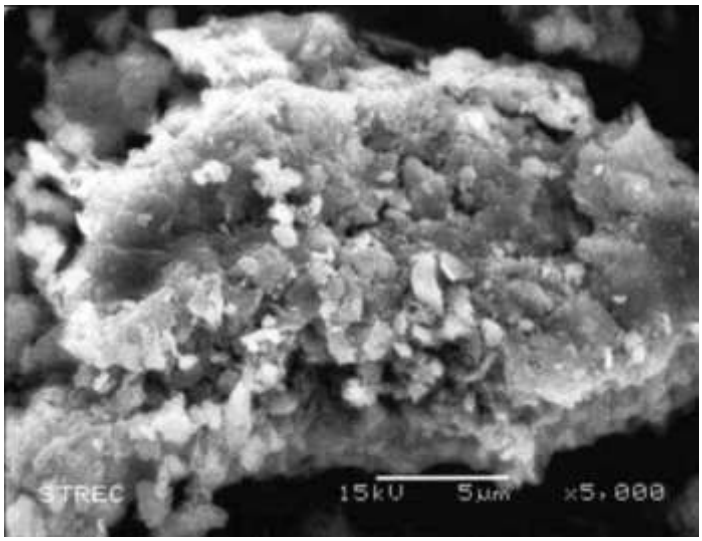

Figure 2: SEM micrograph of sludge (x5,000).

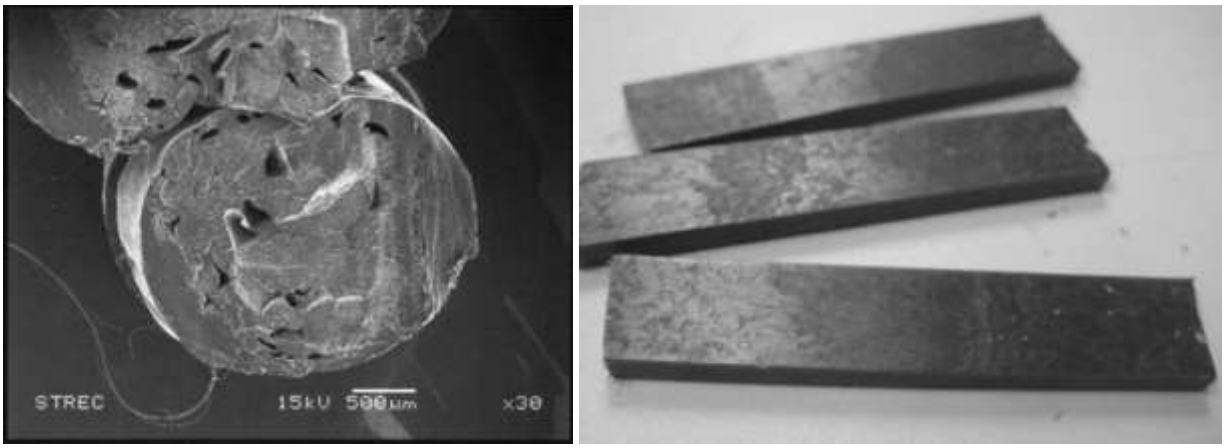

Figure 3: SEM micrograph of cross-section of sludge-LDPE composite pellet (x30) (left), and 5% sludge-LDPE composite plastic (right), by twin screw extrusion.

sludge showed dark green color, whereas lower sludge content showed more light green color, comparatively. Some cavity was observed by SEM and also very rough texture on the sludge-LDPE composite plastic was seen (Figure 3). The sludge continuously mixed in LDPE and increased the opacity of the LDPE plastic.

As shown in Figure 4, it was found that tensile strength of the sludge-LDPE composite plastic samples with all conditions was lower than tensile strength of virgin LDPE with no sludge samples for approx. 3 MPa. However, the tensile strength of other composite plastic samples with different compositions in this experiment was not significantly lower than virgin LDPE with no sludge sample. The data also showed that from all composite samples, the composite material of sludge-LDPE at 5% sludge which 5% coupling agent (AR504) was added had the highest tensile strength. The sludge added to virgin LDPE influenced the increase of ductility and reduction of stiffness of the original LDPE (as shown in Figures 5 and 6), and the elongation and elastic modulus of the sludge-LDPE composite plastic, respectively. Interestingly, the 3% of sludge content had the most elongation (%E) which increased from %E value of the original LDPE with no sludge. Similarly, the 3%sludge resulted in lower elastic modulus, relatively.

As shown in Figure 7, it was found that sludge was affected to reduce impact resistance to approx. 1000 J. The 3% of sludge content in LDPE had the lowest impact strength among them. The impact angle at break of the composite plastics was between 135-138°, increased from

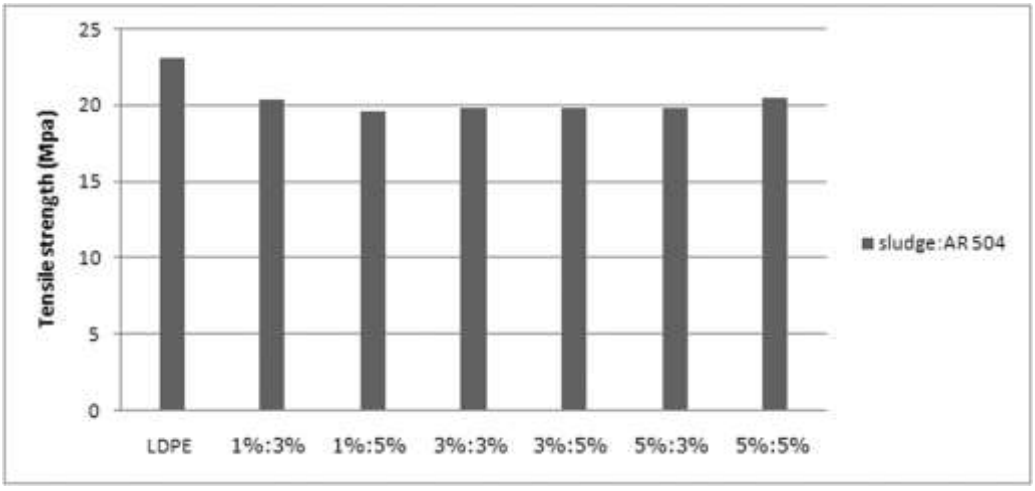

Figure 4: Tensile strength of sludge-LDPE composite plastic.

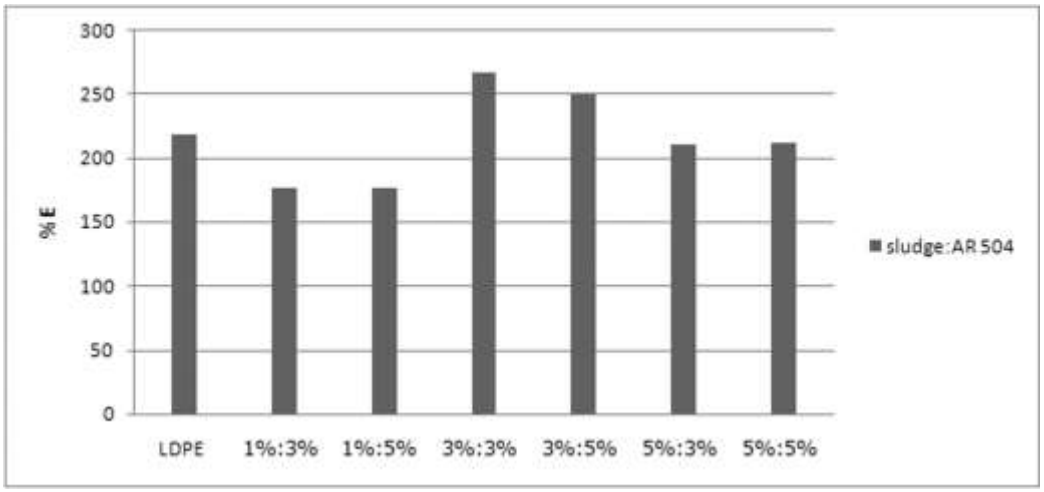

Figure 5: Elongation at break of sludge-LDPE composite plastic.

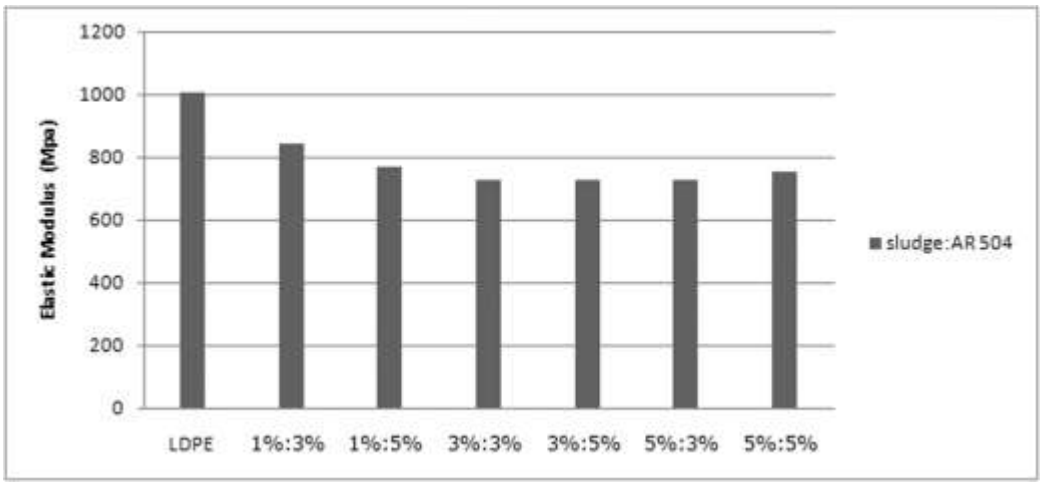

Figure 6: Elastic modulus of sludge-LDPE composite plastic.

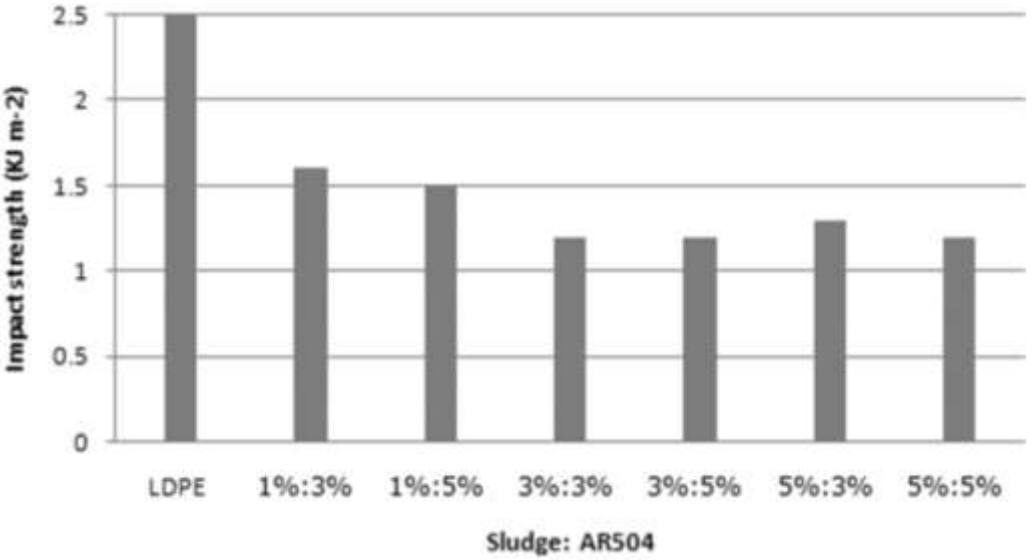

Figure 7: Impact strength of sludge-LDPE composite plastic.

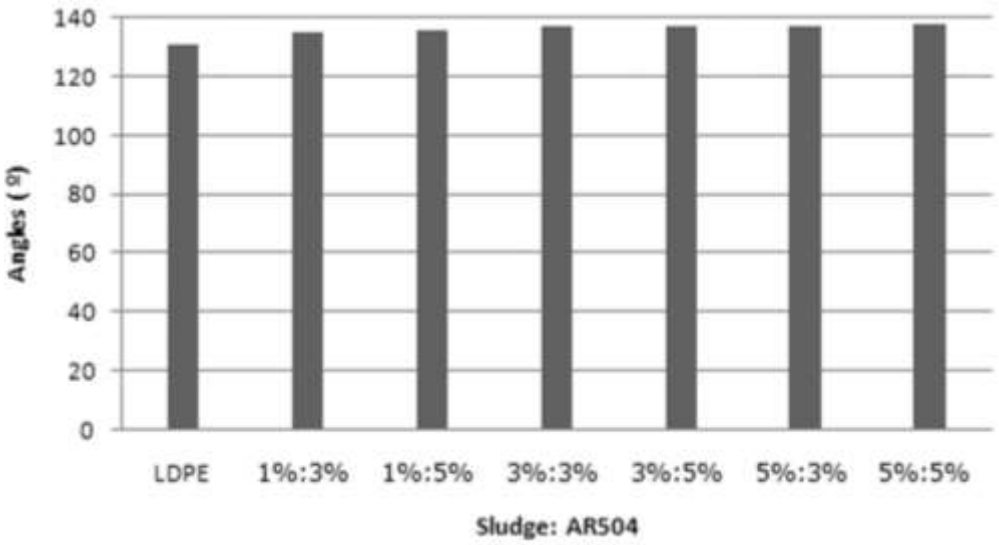

Figure 8: Angles of impact strength of sludge-LDPE composite plastic.

the impact angle at break of the virgin LDPE plastic (131°) (Figure 8). It significantly had relationship between elongation, elastic modulus and impact strength.

Conclusions

It was facile to make the composite plastic from sludge and LDPE via extrusion and injection process. Low density polyethylene can mix with sludge from paperboard making process. The composite plastic made from them had green color and high opacity. The sludge was affected to reduce tensile, impact strength and stiffness of the virgin LDPE plastic, comparatively. However, the influence of coupling agent was not summarized due to insignificantly results. Some different coupling agents are planned to be studied in future work.

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REFERENCES

de la Orden MU, González Sánchez C, González Quesada M, Martínez Urreaga J (2010). "Effect of different coupling agents on the browning of cellulose–polypropylene composites during melt processing". Polym. Degrad. Stab. 95(2): 201-206.

DeArmitt C, Rothon R (2017). " Dispersants and Coupling Agents" in Applied Plastics Engineering Handbook, 2nd Ed., William Andrew: New York, pp. 501-516.

Faruk O, Matuana LM (2008). "Nanoclay reinforced HDPE as a matrix for wood-plastic composites". J. Compos. Sci. Technol. 68(9): 2073-2077.

Ornusa S (2003). "Additives Polymer Book 1" (Chapter7), Chulalongkorn University press: Bangkok, pp.107-114.

Sornnil B (2004). "Plastic Technology" 2nd edition, S.S.T. press, Bangkok, pp. 1-68.

Tandon GP, Wang GJ (1988). "A theory of particle reinforced plasticity". J. Appl. Mech. 55(2): 126-135.

Wypych A (2018). "Maleic anhydride modified polymers" in Databook of Adhesion Promoters, Chem Tec Publishing: Toronto, pp. 162-203.

Yang QS, Qin QH (2001). "Fiber Interactions and Effective Elasto-Plastic Properties of Short-Fiber Composites". J. Compos. Struct. 54(4): 523-528.

Yeh SK, Gupta RK (2008). "Improved wood–plastic composites through better processing". J. Compos. Part A: Appl. Sci. Manufact. 39(11): 1694-1699.

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