博 士 論 文 審 査 の 結 果 の 要 旨

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論文題目	Study on increasing mechanical properties of recycled multi-composition thermoplastic materials by improving interphase performance (界面特性の改善によりリサイクルマルチ熱可塑性材料における機械的性質の向上に関する研究)
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（博士論文審査の結果の要旨）

As Ms. LIN, TING AN has presented in her official presentation, the main purpose of this dissertation entitled “Study on increasing mechanical properties of recycled multi-composition thermoplastic materials by improving interphase performance” is to investigate how to further well recycle the current severe plastic waste issue by an easy and convenient processing method, and reduce the complicated separation cost derived from multi-composition plastic problem including labor, financial and time. The outline of this dissertation is divided into several sections containing the background introduction, performance improvement of multi-composition thermoplastic materials, and cycling effects of mechanical fractures and thermal treatments on the recycled multi-composition materials. This aim focuses on the multi-composition plastic material in a unit not only single-composition plastic material in one unit, and thus it has fulfilled another important issue in the relevant research field. It is expected to have further deep and wide researches based on current results and keep her effort and passion in her future study career.

In this dissertation, Ms. LIN, TING AN has well organized the structure from background introduction including current status, issues, and strategies as following presented (Chapter 1). As mentioned in this section, to date, various types of plastic have been widely employed in diverse fields because they have lots of advantages such as lightweight, lower cost, and good property performance that can be adjusted by the end requirements of users. It is well known that most common and civil products such as food & drink containers (boxes or cups), single-use tableware, and wrapping film are composed of plastic materials, and many of them are made of thermoplastic materials including polypropylene, polyethylene, polyethylene terephthalate, and thermoplastic polyurethane. Although plastic products bring many conveniences to our daily lives, they also cause a huge environmental impact on our circumstances due to their indecomposable characteristic, excessive production, and bad using habits of people. As the plastic problem becomes so uncontrollable, some countries and institutions have promoted some strategies trying to suppress the environmental impact caused by plastic waste. In 2019, at the United Nations Environment Assembly meeting, there are 170 countries have pledged to possibly reduce plastic amount before 2030. In Japan, as one of the leading countries in Asia, decides to ban providing free plastic bags in all retail stores and promises to reduce 25% plastic garbage before 2030. Therefore, how to solve this environmental issue has obtained lots of attention from scholars and researchers. Ms. Lin has pointed out that an appropriate recycling method is important but it is also necessary to maximize the use of existed plastic products rather than throw them away after a single-use. In my personal opinion, one of the difficulties to recycle or reuse the plastic product after first use is the separation problem among the plastic products that contained several components in one product, for example, a drink product may be composed of a PP cap, a TPU film, and a PET bottle. Different plastic materials have different inherent characteristics like melting temperature, molecular weight, chemical composition, and polar nature, and these factors may cause some obstructions like interphase and separation problems in the future recycling processes. Hence, Ms. LIN, TING AN proposed to solve separation problems

of existed plastic wastes by improving the interphase performance among the multi-composition plastic material and expected to increase the reusing probability of plastic materials. The key method in this study is to use compatibilizer playing as bridging role among the multi-composition plastic materials in order to solve the tricky interphase problem. It has changed a viewpoint of compatibilizer in this study, which has generally been employed as a helper to enhance the property performance of blending material or composite materials.

Afterward, the results and discussion sections of this dissertation are constructed in two parts with a logical arrangement containing Part I- Performance Improvement of Recycled Multi-composition Thermoplastic Materials (Chapters 2 and 3) and Part II- Effects of Performance Improvement of Recycled Multi-composition Thermoplastic Materials after Cycling Utilization (Chapter 4). First of all, the multi-composition thermoplastic materials are composed of polypropylene (PP) and thermoplastic polyurethane (TTPU), which both are common plastic materials in the civil product and can make up each other's defects. Chapter 2 focuses on the effects of (1) the composition ratio of various materials and (2) the presence of compatibilizer on the mechanical properties (tensile, flexural, and impact-resistant performances) of multi-composition thermoplastic materials. Based on the results, the tensile stress of multi-composition materials have been slightly increased after adding 5 wt% polypropylene-grafted maleic anhydride (MA) (as bridging role); the impact strength of PP80/TTPU20 with 5 wt% MA has been raised by 135% than 0 wt% MA. The reason for these improvements is mainly contributed by enhancing the interphase performance among the multi-composition thermoplastic materials. Chapter 3 mainly discusses thermal behaviors and morphology observations of multi-composition thermoplastic materials, which have the same compositions in previous chapter 2. From the results of thermal tests (DSC, TGA, and TGA), it is indicated that PP has reinforced the thermal stability of TTPU, which is also slightly improved when MA is added. Besides, SEM images show that the phase separation caused by the polar difference and interfacial tension among the materials is improved after introducing appropriate amount of MA. In the last Chapter 4, the most different part than the previous two chapters is that it mainly investigates the cycling effects of mechanical fractures and thermal treatments on the recycled multi-composition plastic materials after cycling utilization. It is important to evaluate the utilization efficiency of the new plastic materials that been recycled and reformed because the performance will be the most decisive consideration factor and influence the possibility for future applications. The results indicated that the tensile, thermal, formability, and morphology performances of recycled multi-composition materials under interphase improvement have much better results than the recycled group without interphase improvement after cycling use.

In light of this dissertation, it is concluded that the tricky interphase problem among multi-composition thermoplastic materials has been mitigated under the introduction of suitable compatibilizer, and thus diverse property performances have been improved or maintained at a certain level that can increase the using possibility of plastic materials and help solve the plastic waste issue. Moreover, the relevant studies are presented in the following articles that have been accepted and published have more detailed results and explanations. It is recommend that this dissertation can be completed and passed in accordance with the above mentions.

（公表主要論文名）

1. Ting An Lin, Jia-Horng Lin, Limin Bao*, Polypropylene/thermoplastic polyurethane blends: mechanical characterizations, recyclability and sustainable development of thermoplastic materials. Journal of Materials Research and Technology-JMR&T, 2020, 9(3): 5304-5312, https://doi.org/10.1016/j.jmrt.2020.03.056
2. Ting An Lin, Jia-Horng Lin, Limin Bao*, A Study of Reusability Assessment and Thermal Behaviors for Thermoplastic Composite Materials After Melting Process: Polypropylene/ Thermoplastic Polyurethane Blends. JOURNAL OF CLEANER PRODUCTION, 2020, 279, 123473, https://doi.org/10.1016/j.jclepro.2020.123473
3. Ting An Lin, Jia-Horng Lin, Limin Bao*, Effect of Melting–Recycling Cycles and Mechanical Fracture on the Thermoplastic Materials Composed of Thermoplastic Polyurethane and Polypropylene Waste Blends. Applied Sciences-Basel, 2020, 10(17), 5810; https://doi.org/10.3390/app10175810