博 士 論 文 の 内 容 の 要 旨

氏名	LIN, TING AN
学位名	博士（工学）
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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)

（博士論文の内容の要旨）

With the rise of people's awareness of eco-friendly and environmental protection, people have begun to know the importance of the sustainable development of ecological circumstances. It is known that plastic materials are applied in diverse fields due to numerous advantages such as rapid production, lightweight, low cost, and high applicability. However, most of them cannot be naturally degraded and results in a huge amount of plastic wastes, and causes a negative impact on the global environment. It is indicated that recycling is an important concept from the ecological and economical points of view, and the mechanical and thermal behaviors of materials themselves are also critical for recycling processes. To be honest, the repeated thermal treatments (melting and cooling) and mechanical ruptures during the recycling process may result in contamination (water or gas) and poor property performance. Various aspects of plastic's performance would be influenced by multiple thermal treatments if the processing temperature is not under well control and then affected the original performance. Another important issue is that the multi-composition plastic materials are too difficult to be separated and the interphase problem between different plastic components also disturbing the influencing the recycling efficiency during the process. Hence, it is important to solve the interphase problem of multi-composition plastics.

In this dissertation, the main purpose is to investigate a simple and convenient method for multi-composition thermoplastic materials to solve the problems that plastic materials with various compositions cannot be recycled at the same time and to improve the recyclability and sustainable utilization of existed plastic materials and plastic wastes. As one of the most commonly used plastic material employed in various domains, polypropylene (PP) is selected as one of the raw materials, while another one is thermoplastic polyurethane (TTPU). Both of them are thermoplastic materials, namely can be recycled and reused after single-use based on proper conditions. Several types of processing techniques including melt-blending extrusion method, hot-pressing method, and injection method are employed based on different conditions in this study. The study is mainly divided into two parts and 5 chapters, Chapter 1 introduces the general introduction of current issues and background. Part I is " Performance Improvement of Recycled Multi-composition Thermoplastic Materials", and Part II is "Effects of Performance Improvement of Recycled Multi-composition Thermoplastic Materials after Cycling Utilization."

In Part I (Chapters 2 and 3), the recycled multi-composition plastic material is composed of PP as matrix and TTPU as reinforced material. The mechanical properties, morphology observation, and thermal behaviors of multi-composition materials after recycle processes are all investigated. PP /TTPU groups with various composition ratios are melt-blended for two repeated cycles, which a small amount of compatibilizer (i.e. MA) as bridging role is added during the process. SEM images show that groups without MA, TTPU particles demonstrate a dispersive phase in the PP matrix, while the groups

with MA improves the interphase problem between two materials. The impact test results have proven that the incorporation of 20 wt% TTPU and 5 wt% MA helps to improve the interphase problem, thereby yielding the impact strength of 63.01 J/ g. The tensile strength test results show that the presence of PP compensates for the insufficient rigidity and high production cost of TTPU. On the other hand, both of them can be properly heated to reform and reuse due to the inherent characteristics of thermoplastic materials. However, the using efficacy may be compromised as the waste may be overheating and thus damaged during the reheating process. The thermal degradation behavior, melting and crystallization behaviors of multi-composition thermoplastic materials are evaluated under appropriate considerations. In light of the thermal degradation, the presence of thermally stable PP improves the thermal stability of TTPU accordingly. From TGA results, the addition of MA is also helpful, and therefore the third thermal degradation temperature (T3max) is increased by 5oC averagely when compare to neat PP. T1max and T3max of PP/MA/TTPU are postponed about 2 and 4 oC when TTPU content varied from 10 to 30 wt%. In Part II (Chapter 4) is to explore the effect of multiple thermal cycles and mechanical fractures on the recycled multi-composition thermoplastic wastes, and the tensile properties, thermal behaviors and morphology observation are comprehensively discussed. It is known that with appropriate conditions, thermoplastic materials possess a good reversible ability. They are prone to exceed the reversibility range when being repeatedly processed as they cannot bear high temperatures. The feasibility of multiple utilizations and differentiation effects are examined afterward. In this study, recycled or mechanically damaged TTPU/PP and TTPU/PP/MA wastes are used as the raw materials for the hot-pressing cycle, while MA is regarded as a bridging compatible role, thereby simulating various situations of the plastic wastes. Next, the TTPU/PP/MA groups that undergo post-2nd and post-3rd recycling are evaluated for comprehensive change. The test results indicate that without MA, TTPU/PP groups exhibit significant differentiation effects due to an increase in the polypropylene content and multiple melting–recycling cycles. By contrast, the presence of MA mitigates the differentiation effect of TTPU/PP groups.

As a result, Chapter 5 concludes that this study attenuates the negative influences of plastic waste on the environment while achieving sustainable development. it is indicated that the addition of compatibilizer significantly helps solve the typical issues – interphase problems between the different plastic materials and thus have a positive contribution to the sustainable development of existed multi-composition plastics. Not only for the existed plastics but also for plastic wastes, the results have indicated the reusing efficiency and possibility in the subsequent recycling process and future applications.