博 士 論 文 審 査 の 結 果 の 要 旨

氏名	LIN, MEI-CHEN
学位名	博士（工学）
学位番号	甲　第 785 号
論文題目	Development of flexible carbon fiber reinforced composite fabrics with knitting structure **編み構造を使用した柔軟な炭素繊維強化複合材料の開発**
論文審査委員	主査　鮑　力民 森川　英明 坂口　明男 朱　春紅 Wen-Cheng Chen　（Feng Chia University）

（博士論文審査の結果の要旨）

Ms. MEI-CHEN LIN was admitted in April 2019, and the title of her doctoral dissertation is "Development of flexible carbon fiber reinforced composite fabrics with knitting structure". In the dissertation, the main purpose is to develop a new type of carbon fiber composite material, which can increase the friction and deformability of carbon fiber by wrapping, so that carbon fiber can be used for the preparation of knitted fabrics. Through the research results of the dissertation, the application field of carbon fiber composite materials can be increased. The dissertation is divided into six parts, including the background introduction, the production of composite carbon fibers, the discussion of the composition parameters of composite carbon fibers, and finally the study on fabrics and composite materials prepared from composite carbon fibers. This dissertation makes a new contribution to the application of row carbon fiber tow and its integration with thermoplastic composites. The structural design and discussion of carbon fiber thermoplastic composites are diverse. I hope that MEI-CHEN LIN can continue the research results in the future, conduct further in-depth and extensive research on the basis of the existing results, and maintain her efforts and enthusiasm in the future.

In the first chapter of the dissertation, Ms. MEI-CHEN LIN organized the structure well, including the current status, problems and strategies of carbon fiber composites, and gave a comprehensive introduction to the processing methods and composite structures. As presented in this chapter, resin-based fiber-reinforced composites can be divided into two categories: thermoset and thermoplastic. At a time when the awareness of environmental protection is rising and the circular economy has become a hot topic, thermoplastic composites will soften again due to heating, and have the characteristics of plastic formability, mass production, high reprocessing and recyclability, and have the opportunity to gradually replace them. Current thermosetting composite materials that are difficult to recycle. Carbon fiber composite materials are mainly composed of polymer resins and fiber materials, and are mostly used in products that require lightweight, high strength and high rigidity, such as aerospace, ships, automobiles, sports equipment, and industrial production equipment. With the rise of circular economy issues, energy saving, carbon emission reduction, waste reduction, recyclability and reuse have become important considerations for the development of new materials at this stage. In composite materials, carbon fiber plays the role of reinforcing material and mainly bears external force; resin matrix transmits stress load to carbon fiber in the form of shear stress through the interface. At the same time, resin matrix also protects carbon fiber from direct external damage, especially Is a carbon fiber fabric used in the weaving process.

In the second to fifth chapters of the dissertation, the development process and evaluation of composite carbon fibers are presented. In the dissertation arrangement, a new carbon fiber composite material is first developed, and it is expected that the main purpose of weaving is to improve the friction properties of carbon fiber through the method of covering. The results in Chapter 2 show that the friction properties of the

composite carbon fibers are improved after TPU coating. Next, according to the parameters that can affect the structure of the carbon fiber composite material, the composition of the outer layer and the fiber content of the inner layer are respectively changed and discussed. Among them, the composition of the outer layer uses two different thermoplastic resins (thermoplastic polyurethane) to change the clustering effect of the coating layer according to the molecular weight and viscosity. The results in Chapter 3 show that when the ratio of the two TPUs is 85/15 At wt%, the composite carbon fiber has an elliptical shape, and the mixed TPU can reinforce the tensile strength of the composite material. Next, the fiber content of the inner layer is discussed in Chapter 4, and three different fiber tows contents can be used to make composite carbon fibers. But excessive fiber counts can lead to poor wrapping and weaving results. This is due to the inability of the thin outer layer to gather fiber tows well, resulting in a flat cross-sectional shape of the composite. In addition, this flat cross-sectional configuration can cause the composite to turn over during weaving. After that, the optimal parameters of the front part are made into carbon fiber composite materials of knitted structure and laminated. The improved carbon fiber tows are well demonstrated in the results of Chapter 5. The finished product has good deformability and retains the ductility provided by the knitted fabric loops. This is a breakthrough for flexible carbon fiber composites, which are transformed from original high stiffness characteristics to high strain characteristics. Throughout the study, the results for morphology and tensile strength also confirmed the reliability of the cladding. In addition to this, the composite material provides good electromagnetic wave shielding, which is an added functionality.

The conclusion of the dissertation is integrated in the sixth chapter, which combines the processing technology of long fiber composite materials, co-extrusion and hot pressing processing technology in the study. The continuous carbon fiber composite material is covered with TPU, the purpose is to increase the flexural Flex of the carbon fiber composite material and expand the application field. Continuous carbon fiber tows can be directly processed into a three-dimensional composite material with knitted structure and properties. In addition, carbon fiber composite materials have good electromagnetic shielding ability and high flexibility, and large-scale composite materials can also be fabricated. This research breaks through the current limitations of continuous carbon fiber processing technology and can be applied to the field of carbon fiber composite material preparation. Moreover, the relevant studies are presented in the following articles that have been accepted and published have more detailed results and explanations. It is recommending that this dissertation can be completed and passed in accordance with the above mentions.

（公表主要論文名）

1. Mei-Chen Lin, Jia-Horng Lin, Limin Bao*. Combination and Development of Carbon Filament Tows: Application of Coextrusion with Long Fiber-Reinforced Thermoplastics. *Polymer Composites*. 2021, 42(9): 4199-4206.
2. Mei-Chen Lin, Jia-Horng Lin, Limin Bao*. Applying TPU blends and composite carbon fibers to flexible electromagnetic-shielding fabrics: Long-fiber-reinforced thermoplastics technique. *Composites Part A: Applied Science and Manufacturing*. 2020, 138(17): 106022.
3. Mei-Chen Lin, Jia-Horng Lin, Limin Bao*. Thermoplastic Polyurethane Reinforced with Continuous Carbon Fiber Tows: Manufacturing Technique and Fabric Property Evaluation. *Applied Composite Materials*. 2021, 28, 1531-1546.
4. Mei-Chen Lin, Jia-Horng Lin, Limin Bao*. Extrusion/Hot Pressing Processing and Laminated Layers of Continuous Carbon Fiber/Thermoplastic Polyurethane Knitted Composites. *Polymer International*. 2021, https://doi.org/10.1002/pi.6325.