

論文内容の要旨

専攻名 共生環境学

氏 名 CAI ZIYI



題 目 Study on multiple utilization of agricultural and forestry waste biomass
(農林廃棄バイオマスの複合的利用に関する研究)

With the continuous growth of the global population, the demand for food crops has been steadily increasing. After harvesting, a large number of inedible by-products are generated. The three major food crops—maize, rice, and wheat—produce approximately 1.05 billion tons, 540 million tons, and 820 million tons of straw annually, respectively. Most of this straw is either plowed back into the fields or burned, while a smaller portion is used as fuel. Meanwhile, wood processing generates waste materials such as sawdust and pruned branches, which are often used in the production of fiber board. However, traditional fiberboard contains a significant number of adhesives, which release harmful substances such as formaldehyde during use, posing risks to human health. In addition, the substrates used for industrialized mushroom cultivation are primarily made of sawdust, with mycelium introduced to facilitate mushroom growth. Since the spent mushroom substrates (SMS) contain mycelium and exhibit adhesive properties, they can be used to produce bio-boards through both dry and wet processing techniques.

The aim of this study is to utilize agricultural and forestry wastes to develop biodegradable fiberboard(bio-board) without the use of any adhesives. The formation of the bio-boards primarily relies on hydrogen bonding between fibers and the adhesive properties of mycelium. By evaluating the mechanical strength and water absorption properties of the bio-boards, their potential to replace traditional fiberboards can be determined. Additionally, the study explores their application potential in fields such as building materials and packaging materials to expand their range of uses. The produced bio-boards exhibited a density ranging from 0.90 to 1.34 g/cm³ and a moisture content of 3.64% to 9.91%. The bending rupture stress at fracture ranged from 15.44 to 44.14 MPa, while the tensile rupture stress ranged from 4.72 to 24.18 MPa. Experimental results indicated that the performance of the bio-boards improved significantly with increasing applied pressure and heating temperature.

For the SMS, under wet processing conditions, the maximum bending rupture stress reached 36.60 MPa at a applied pressure of 11 MPa and a heating temperature of 160°C. Given the high applied pressure, it was observed that applied pressure significantly influences the strength of bio-boards. Furthermore, under the same conditions, the bio-boards produced using the wet method exhibited higher strength than those produced using the dry method. To develop bio-boards with improved performance, the three materials were mixed to create a hybrid bio-board. When the mixing ratio of soybean straw to camphor pruned branches was 3:1, with a applied pressure of 5 MPa and a heating temperature of

(備考) 日本語 (2000字以内) 又は英語 (500ワード以内) にまとめて記載してください。

200°C, the maximum bending rupture stress reached 44.14 MPa. This result can be attributed to the fact that bio-boards made from soybean straw exhibit significantly higher strength compared to those made from camphor pruned branches. Therefore, it is concluded that bio-boards with a higher proportion of soybean straw can achieve superior strength.

Finally, although used bio-boards can be directly released into the environment, their degradation cycle remains relatively long. Therefore, carbonization tests were conducted on the waste bio-boards to calculate their energy activation and pre-exponential factors, considering their potential use as fuel. The carbonization test results showed that bio-boards made from soybean straw and camphor pruned branches exhibited higher activation energy, requiring more energy for carbonization. The bio-boards produced in this study were manufactured without the use of adhesives or chemical synthetic agents, relying instead on hydrogen bonding between fibers and the binding force of mycelium. These bio-boards are biodegradable biomass materials. Furthermore, by demonstrating their potential use as fuel after their service life, this study highlights the critical role of biomass resources in promoting sustainable development for humanity.