

# Abstract

Upcycling abandoned beehives to make new products can reuse the useful materials in old beehives and produce less trash. As known that bees leave their beehive in these following situations like insufficient replenishment, frequent unboxing and environmental issues. Then the beehive will be abandoned and will have no use left.

In this project, a piece of honeycomb was collected from abandoned beehive and melted in order to extract beeswax. The potential of the extracted beeswax for replacing plastic to produce fillers of 3D pens was studied. Natural materials like seashell, rosin, soy bean and coffee ground were tested as ingredients of 3D printing materials.

Finally, the potential of using extracted beeswax in 3D printing was confirmed. Beeswax has a low melting point at around 64°C and solidify quickly at room temperature. The high plasticity of this natural wax fulfills the criteria of 3D printing materials. Biodegradable wastes, like **coffee grounds and soy bean grounds** were tested as additives for reducing the beeswax content. Sea shell grounds were eliminated from the tested list as its filaments broke into small pieces of brittle fragments during the production process. **5% and 10%** of these additives were the optimal formula for making long filaments.

Yet, the thin filaments made by pure beeswax were not strong enough, filaments of **selected beeswax-soy bean grounds** were further strengthened by **mixing with 5% or 10% rosin**. Among the four different ratios of Beeswax: Soy bean grounds: Rosin (9:1:0.5 / 9:1:1 / 9.5:0.5:0.5 / 9.5:0.5:1), filaments in the ratio 9.5:0.5:0.5 demonstrated better flexibility, higher tensile strength and compressive strength, thus **B9.5:S0.5:R0.5** was the final formula of biodegradable beeswax 3D filament.

# 簡介

將被蜜蜂所遺棄的蜂巢升級再造新產品可以善用舊蜂巢中的可用物質並減少垃圾產生。在以下的情況，蜜蜂會選擇離開它們的蜂巢，例如食物補給不足、頻繁拆箱取蜜和不良環境因素等。蜜蜂遺下的蜂巢或人造蜂箱就成了被棄置並且沒有任何用處的垃圾。

在這項研究中，我們從廢棄的蜂巢中收集了一塊蜂窩，並將其融化以提取蜂蠟。目的為探究從蜂巢中提取的蜂蠟能否替代塑膠原料來生產 3D 打印機或打印筆的填充物。我們分別測試了貝殼、松香、大豆和咖啡粉等天然材料能否用作為 3D 打印材料的成分。

最後，我們確定了蜂蠟在替代 3D 打印中使用的塑膠原料的潛力。蜂蠟的熔點較低，約為 64°C，它並能在室溫下會迅速凝固。這種天然蠟質的高可塑性符合 3D 打印材料的標準。雖然由純蜂蠟製成的幼線很脆弱易斷，但添加可生物降解的廢物，如咖啡渣和大豆渣能減少所需的蜂蠟含量。而貝殼粉則被排除在測試清單之外，因為它的幼線在生產過程中容易破碎成小塊的碎片，不能成形。5% 和 10% 的添加劑是製造長幼線的最佳配方。

通過添加 5% 或 10% 松香能有效進一步加強蜂蠟-咖啡渣和蜂蠟-大豆渣幼線的強韌度。在蜂蠟的四種不同比例中：大豆渣：松香（9:1:0.5 / 9:1:1 / 9.5:0.5:0.5 / 9.5:0.5:1），比例為 9.5:0.5:0.5 的幼線表現良好柔韌性，更高的拉伸強度和壓縮強度，因此 B9.5 : S0.5 : R0.5 是可生物降解蜂蠟 3D 幼線的最終配方。