DEFINING THE CRITICAL TEMPERATURE FOR POWDER OF PLANTS FROM THE CROATIAN COAST USED IN THE PRODUCTION OF 3D PRINTED FILAMENTS

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ABSTRACT

Recently, plants have been increasingly used as a resource for various industries, including additive manufacturing (i.e. 3D printing) due to their natural and biodegradable properties. In order to improve the environmental acceptability of the base material for the filament production, in this study, powder obtained from plants collected on the Croatian coast was analysed as a possible sustainable biofiller. In the extrusion process of filament production and in 3D printing itself, temperature plays a key role for the melting and interlayer adhesion of polymer materials. Thus, the colorimetric grayscale and mass stability of four plant powders (mint, rosemary, lavender and wormwood) were studied at a temperature range from 140 °C to 230 °C. It was observed that for all analysed plant powders, the critical temperature for mass loss was 200 °C, except for lavender, where the critical temperature was 220 °C. The same temperature was critical for colour degradation for all analysed plant powders, with no plant being singled out.

MATERIALS AND METHODS

Four plant powders were used:
(1) Mint (Mentha × piperita L.)
(2) Rosemary (Salvia rosmarinus, formerly Rosmarinus officinalis L.)
(3) Lavender (genus Lavandula)
(4) Wormwood (Artemisia absinthium L.)

Temperature treatments
All plant powders were placed in porcelain crucibles and subjected to temperature treatments from 140 to 230 °C. The treatment was carried out in a Nabertherm L9/11 B180 Muffle Furnace where the program set to expose the samples for 10 minutes at each defined temperature.

Mass loss analysis
Porcelain pots containing plant powder were weighed before and after each treatment using a KERN ABT 220 analytical balance to determine mass loss Δm (%).

Color degradation analysis
Color degradation was assessed by photographing all porcelain pots with plant powder before and after temperature treatments using a Dino-Lite digital microscope at a constant distance and a magnification of 11.3x. Images were converted to monochrome images using ImageJ to measure the mean grayscale value and the change in mean grayscale value before and after treatment (ΔGS).

RESULTS

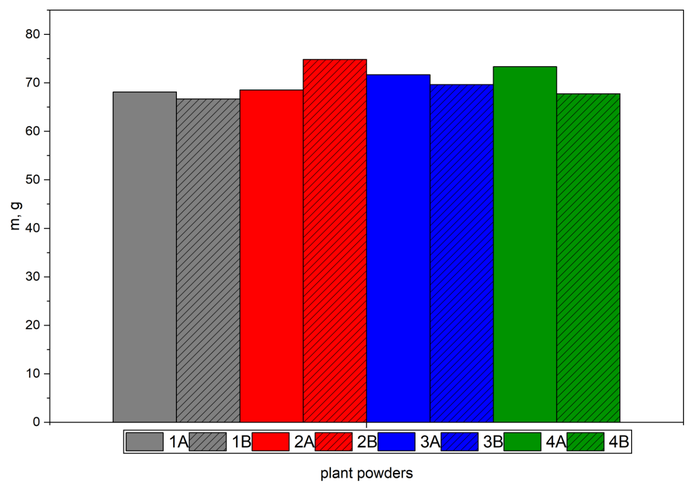

Figure 1. Initial mass value of plant powders

To reduce the waiting time for samples to cool before weighing and the energy loss when heating in the Muffle Furnace from each plant powder, the analysis was performed from two different initial masses (A and B).
Marks 1A-4A were used for temperatures of 140 °C, 160 °C, 180 °C, 200 °C and 220 °C, while 1B-4B were used for temperatures of 150 °C, 170 °C, 190 °C, 210 °C and 230 °C (Figures 1, 3-4).

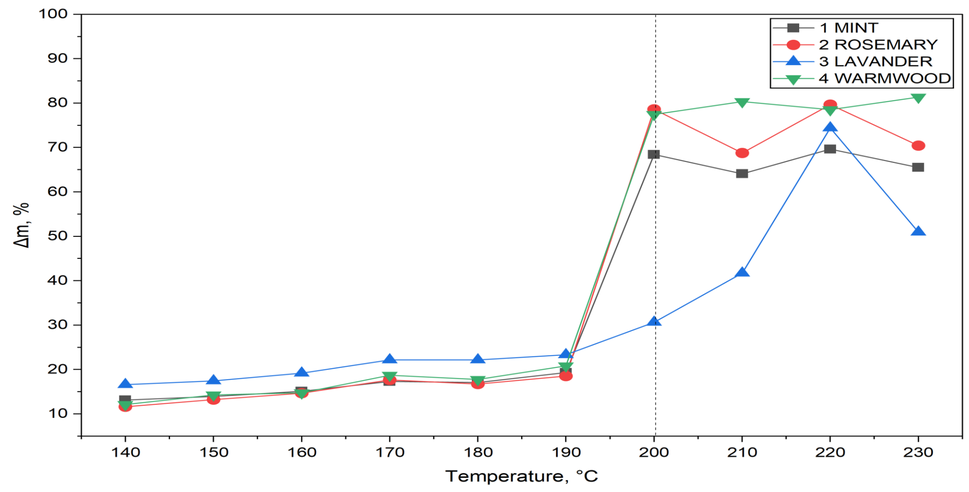

Figure 2. Mass loss of plant powders

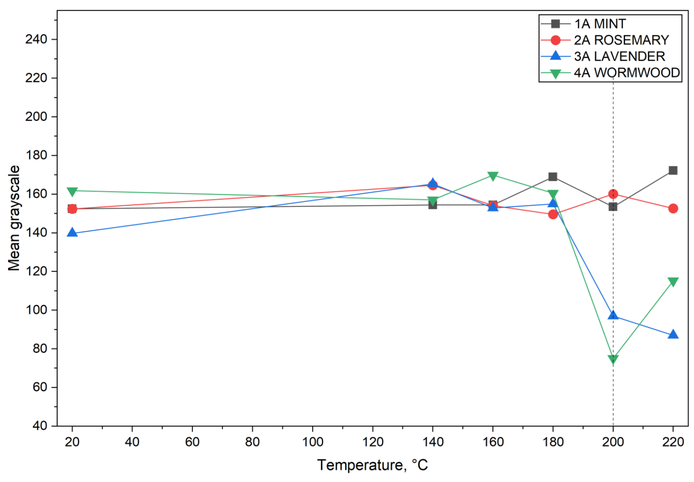

Figure 3. The mean grayscale value of plant powders (1A-4A)

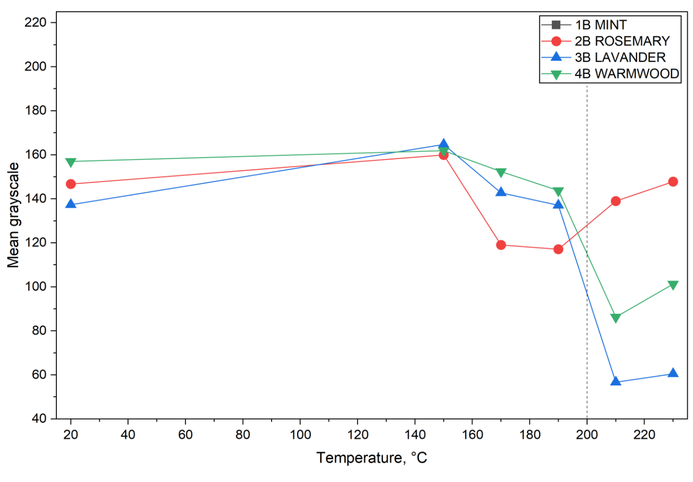

Figure 4. The mean grayscale value of plant powders (1B-4B)

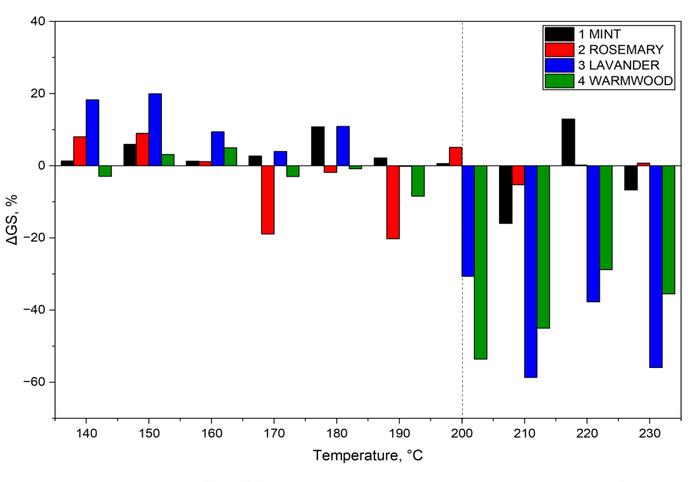

Figure 5. Difference of mean grayscale value before and after temperature treatment

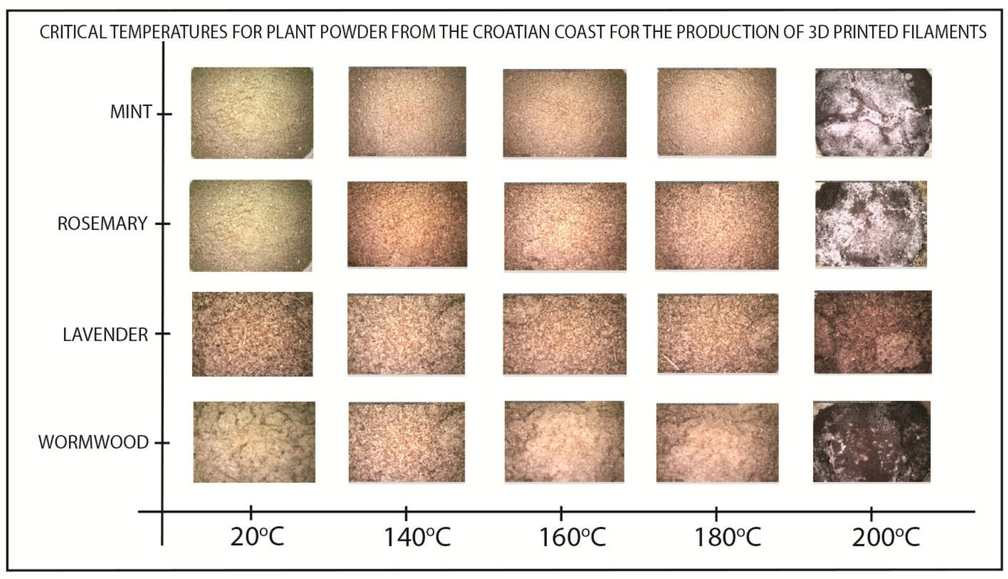

Figure 6. Images of plant powder obtained before and after thermal treatments

Observing Figures 3-6, it can be seen that the lavender plant is somewhat more stable compared to other plants. Plant lavender contains a higher percentage of lignin compared to other plants, which is the most thermally stable component of biomass. Its pyrolysis and decomposition begin only above 200 °C.

CONCLUSION

In this study, powder obtained from plants collected on the Croatian coast was analyzed as a possible sustainable biofiller. In the extrusion process of filament production and ultimately in the 3D printing itself, temperature plays a key role in polymeric materials. This study was conducted as a preliminary study to understand the critical points in the production of filaments with plant powder. The studied colorimetric stability of the gray scale and mass of four plant powders (mint, rosemary, lavender and wormwood) in the temperature range from 140°C to 230°C show that pyrolysis begins at 200°C and is followed by carbonization. Under the influence of high heat (200 °C), complex organic compounds in the leaf (cellulose, lignin, hemicellulose) begin to chemically decompose into simpler substances. While the reason why the plant loses its natural green color and becomes completely black is charring or carbonization. It was observed that for all analyzed plant powders, the critical temperature for mass loss was 200°C, except for lavender, where the critical temperature was 220°C.

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