Green composites for fertilizer controlled release produced by compression molding and FDM

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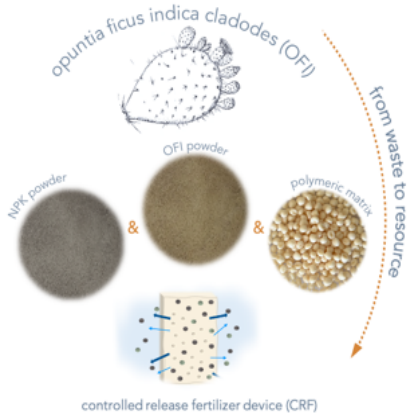
ABSTRACT

Excessive fertilization causes ecological problems due to leaching issues. To solve this problem and promote agriculture sustainability an **innovative green composite for controlled release fertilizers** (CRF). The final goal of the present work was to produce CRFs devices by adding NPK flour to a biopolymeric matrix (Mater-Bi®) with or without Opuntia Ficus Indica (OFI) particles. For NPK and OFI flours two different granulometry (<75 µm and 75–300 µm) were use and six formulations of biocomposites were produced and employed for the realization of CRF devices both for **compression molding** (CM) and **fused deposition modeling** (FDM). Photo of the obtained samples are reported in Fig.1. Ultimately, the aim of this work is to control the release rate of NPK, chosen as model fertilizer compound, by embedding it on a compostable matrix and by exploring the possibility to tune the release from MB and MB/OFI composites by modifying flours granulometry and production techniques. To verify the achievement of this goal, release tests were performed and Peppas-Korsmeyer mathematical model was applied to modelize the obtained data.

Preparation



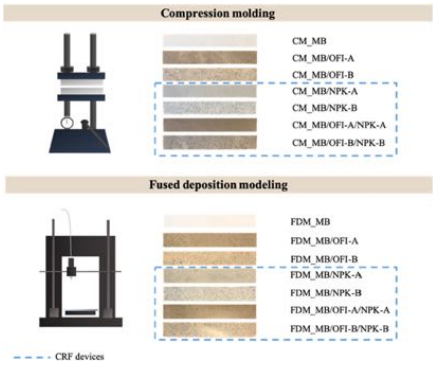


Fig. 1. FDM- and CM- samples (photo). CRF composites have been highlighted with dashed rectangles.

Morphological analysis

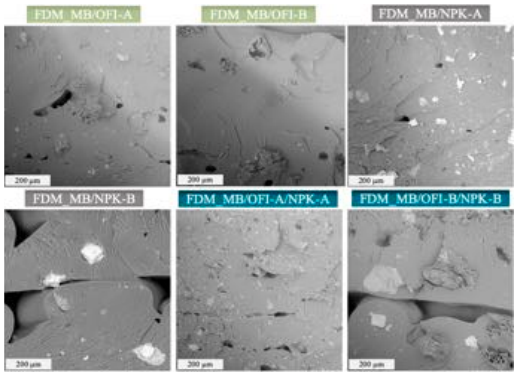
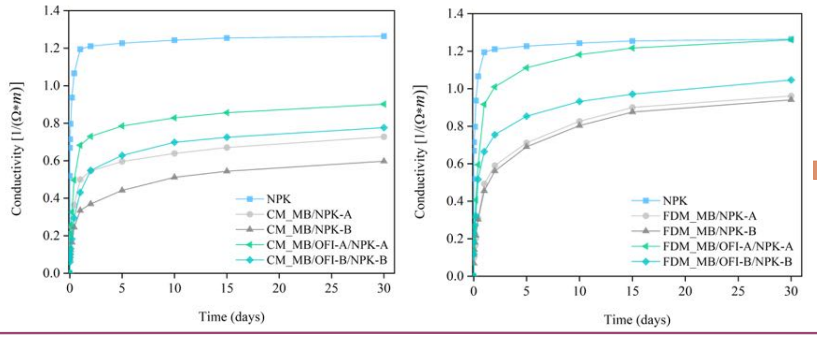


Fig. 2. SEM micrograph of fractured cross-section of green composites and CRF devices fabricated for CM and FDM.

NPK release

Release tests of CRF devices reveal the ability of all the obtained composites to slow the release rate of NPK (up to 30 days), which proved to be tunable by modifying formulation, flours granulometry and production techniques (**Fig. 4**).

FDM_MB/OFI-A/NPK-A act as the best CRF device showing a remarkable burst delivery with about 70% of NPK released in the first 24 hours and a 100% release after 30 days.



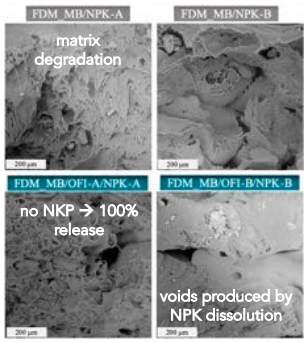
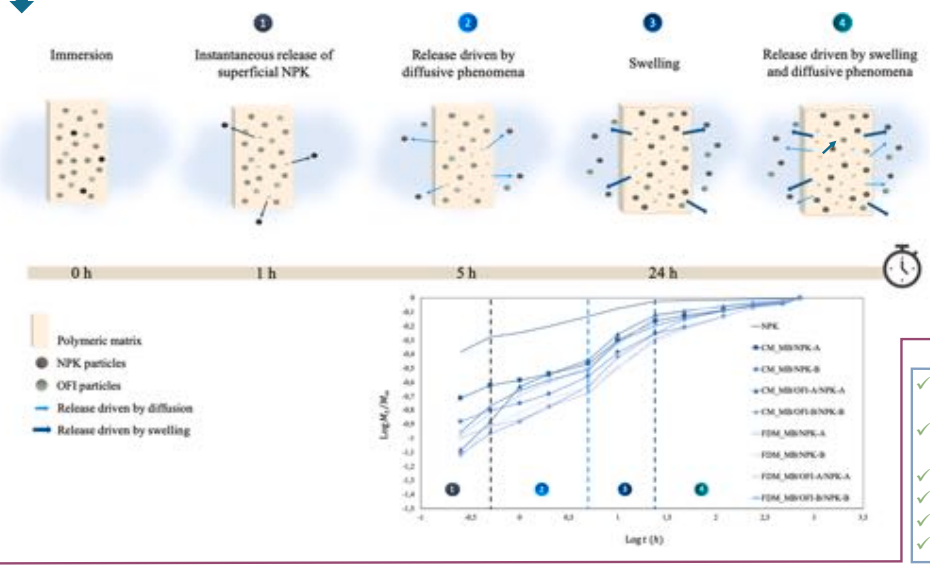


Fig. 3. SEM micrograph of fractured cross-section of CRF devices after soaking in water for 30 days.

Peppas-Korsmeyer model - release mechanism

Logarithmic plots of obtained NPK release data as a function of time were evaluated to understand better the fertilizer release mechanism.

Fig. 5 provides a pictorial description of the release mechanism of the CRF composites.



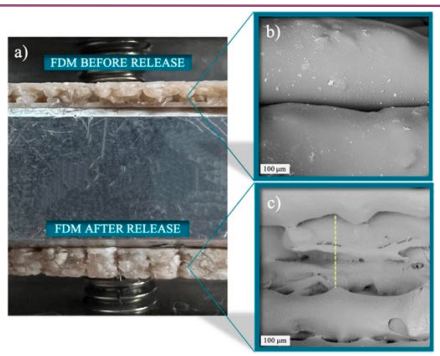


Fig. 6. Optical image (a) and SEM micrograph of good adhesion between layers in FDM samples before NPK release (b) and layers detachment in FDM samples after soaking in water for 30 days due to occurrence of swelling (c).

CONCLUSIONS

- ✓ An **innovative green composite** for CRF was produced using OFI scraps
- ✓ NPK fertilizer and OFI powders were successfully **dispersed** and **embedded** into a biopolymeric matrix
- ✓ Biocomposites were processed by **CM** and **FDM**
- ✓ NPK and OFI particles effectively act as reinforcement
- ✓ Devices showed a **tunable NPK release** rate
- ✓ The decrease of NPK release rate up to 30 days was achieved