PÔSTER - RESUMO - MATERIAIS E BIOMATERIAIS

SUSTAINABLE DEVICES FOR NUTRIENT DELIVERY

Gabriela Bueno De Godoy (gabrielagodoy@usp.br)

Roselena Faez (faez@ufscar.br)

Agriculture constitutes one of the main pillars of human civilization, being essential for food security and sustainable development. In view of the population growth projected by the United Nations, it is estimated that food production must increase by up to 70% by 2050 in order to meet global demand. In this context, the Sustainable Development Goals (SDGs) were established, defining targets aimed at promoting sustainable, social, economic, and environmental development, with emphasis on Zero Hunger (SDG 2) and Responsible Consumption and Production (SDG 12). The development of new technologies becomes fundamental to achieving these goals. In this study, enhanced-efficiency fertilizer devices were developed and evaluated, using cellulose nanofibers (CNF) and thermoplastic starch (TPS) as barriers materials for monoammonium phosphate fertilizer (MAP, NH4H2PO4). MAP is widely used in agriculture as an important source of nitrogen (N) and phosphorus (P), which are essential nutrients for plant physiological and biochemical processes. Initially, MAP was coated with CNF by spray drying under previously optimized conditions (temperature: 140 °C; feed: 100%; pump: 10%), resulting in the formation of microspheres (MsMAP). The MsMAP were incorporated into the TPS matrix at a proportion of 50% through melt processing in an internal mixer (110 °C; 60 rpm; 5 min), yielding the TPS/MsMAP device. The MsMAP and TPS/MsMAP devices were evaluated in an aqueous medium using two

complementary analytical approaches: ionic conductivity (IC), to monitor total ion release, and ionic quantification (IQ) of ammonium (NH_4^+) and phosphate (PO_4^{3-}) ions, since the salt is not present in its elemental form. For IC assays, 0.50 g of each sample were placed in impermeable sachets and immersed in 100 mL of Milli-Q water. Measurements were recorded between 0 and 360 min using a Gehaka CG2000 conductivity meter, and the value obtained after 24 h was considered as 100% release. For IQ analysis, 0.25 g of each sample were immersed in 50 mL of distilled water, with the sachets transferred to new containers at predetermined time intervals, ranging from minutes to seven days. All analyses were performed in triplicate, and quantification was carried out by UV–Vis spectrophotometry (GENESYS 180, Thermo Scientific) according to established methodologies. Both assays were evaluated in triplicate. The IC results indicated that the incorporation of CNF into MsMAP delayed fertilizer dissolution, with complete release occurring after approximately 15 min, demonstrating the role of the fibrous network as a diffusion barrier. For the TPS/MsMAP system, an additional delay was observed, with total release occurring after approximately 30 min, reflecting the combined effect of CNF and TPS. In the IQ assays, MsMAP exhibited a faster initial release of NH_4^+, reaching approximately 80% within the first 20 min and 90% after 120 min, while TPS/MsMAP released about 75% and 90% over the same intervals. For PO_4^{3-}, MsMAP reached approximately 98% release within 20 min, whereas TPS/MsMAP reached 95% only after 40 min, indicating greater phosphorus retention compared to nitrogen. This behavior suggests a predominantly initial release of N, followed by gradual P release, favoring nutrient supply over time. Furthermore, the results indicate that the higher surface area of the microspheres contributes to rapid initial dissolution, while the TPS matrix acts as an additional physical barrier, delaying nutrient diffusion. Thus, the developed devices exhibit promising potential for controlled-release performance, representing a sustainable alternative for intensifying agricultural production and meeting the SDGs. This study was supported by CAPES (Finance Code 001), FAPESP (Grant 2024/08036-9), and the National Institute of Organic and Sustainable Electronics. (INEO-INCT). Institutional and academic support, including research infrastructure, was provided by the Federal University of São Carlos (UFSCar) of São Paulo (USP/FZEA) and the Graduate Program in Materials Engineering (PPG-EnCiMat/FZEA-USP).

Palavras-chave: enhanced-efficiency fertilizers; controlled nutrient release; biopolymer-based devices; spray drying; sustainable agriculture.