Porous Urea-Biopolymer Composites – A Preparation Method with Supercritical Carbon Dioxide

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Groundwater pollution through nitrate leaching is a current problem in agriculture. A controlled nitrate supply offers a solution to this problem. A fertilizer system that supplies plants with the nitrate needed as required would save resources and at the same time protect the environment. Often an encapsulated system is used as the dosage form. The capsule material forms a physical barrier to the environment and thus prevents a sudden release of the nitrogenous substance. To be able to control the release behavior, the structure of the carrier matrix has to be specifically built. To prevent a contamination of the soil by capsule materials, it is advantageous if these are biodegradable. Thus biodegradable and bio-based polymers are a sustainable alternative for use in agricultural products.
For the production of a nitrogen fertilizer depot, polylactic acid (PLA) was used as carrier matrix and urea as model substance. To form a porous composite of both substances, the discontinuous antisolvent process was used. Here, chloroform is applied as the organic solvent, PLA as solute, and CO_2 as the antisolvent. Different viewing cells were used to produce the PLA composites at temperatures from 25 °C to 40 °C and pressures from 10 MPa to 18 MPa. The mass fraction of urea was varied to 70 %. In addition to a detailed parameter study for the antisolvent process, the produced composites were also characterized. The surface quality and shape of the composites were determined with a scanning electron microscope (SEM). Also, the density was examined to calculate the porosity of the composites. It was found that the closed pores of the composites mostly have an oval or spherical shape, with an average pore size of 100 µm to 250 µm. Furthermore, the SEM images show that urea is highly dispersed throughout the porous composites, with a higher concentration at the bottom of the sample. By leaching experiments, it is possible to observe only the porous PLA matrix structure. In figure 1, the calculated porosity of 50 wt.% and 70 wt.% urea loaded and leached out composites is shown on the left side and the complementary SEM images for 18 MPa on the right side. The porosity of the leached out samples is between 75 % and 83 %, whereby this also depends on the system pressure.

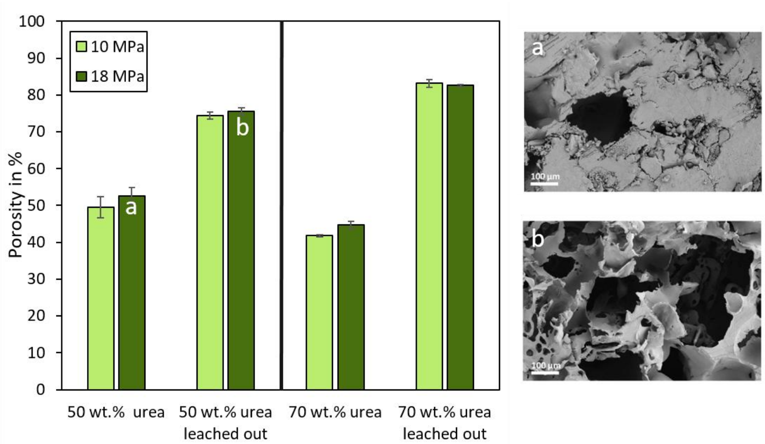

Figure 1: Porosities for 50 wt.% and 70 wt.% urea loaded and leached out composites at 10 and 18 MPa (left) and SEM images of a) urea loaded and b) leached out composites at 18 MPa (right)

To investigate the leaching rate of urea from the composite, a flow cell and high-performance liquid chromatography were used. Since the release behavior depends on the flow rate and usually takes several days, it is possible to evaluate the potential applications in the agricultural industry.