

FUNCTIONAL POLYMERS FROM POLY(3-HYDROXYALKANOATES): PROTECTION OF SURFACES FROM BIOFOULING

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INTRODUCTION: Plants are constantly exposed to harmful attacks by fungi, viruses, bacteria or insects. In order to protect themselves some plants developed various repulsion mechanisms. For example, the eelgrass *Zostera Marina L.*, which has its biotope in saltwater bays and harbors, is attacked by marine bacteria or spores. For self-protection, the eelgrass produces and releases constantly the antifouling compound zosteric acid (ZA), a sodium salt of a sulfated phenolic acid. This compound does not kill the microorganisms but inhibits the adhesion of the biological organism. The aim of our project was to develop a novel protection strategy, namely the combination of a biodegradable and biocompatible matrix (poly(3-hydroxyalkanoate); PHA) with environmentally friendly antifoulant (ZA) encapsulated in polystyrene (PS) (Fig. 1).

METHODS: Encapsulation of ZA in polystyrene (PS) was performed via an in-liquid-drying process. The particle size of the microcapsules was measured with the Beckman Coulter particle size analyzer LS230. The morphology of the capsule surface was examined by electron microscopy and cross-sections of microcapsules were prepared with a focused ion beam instrument. After dissolving the PS microcapsules in an organic solvent and extraction of the ZA with water the payload was determined by conductometry. ZA was monitored via ESCA measurements in the inner part of the PS microcapsules. The PHA/PS(ZA) coatings were applied by air brush on glass microscope slides. The release of the ZA out of the coating was monitored again using conductometry.

RESULTS: We demonstrated the possibility to encapsulate the highly water soluble ZA by incorporating the sodium salt in a PS matrix via an in-liquid-drying process. Therefore, a high viscous methylene chloride solution of PS was prepared which represented the oil phase in the OW-emulsion. Subsequently, the ZA powder was dispersed in this polymer solution. Due to the high viscosity of the mixture the ZA was hindered to dissolve in the water phase of the emulsion during dispersion. Shortly after microcapsule formation the methylene chloride evaporated. The solid PS capsules were collected. Capsules were formed with a polydisperse distribution of an average size of 200 μm . The surfaces of the capsules were smooth without failures as proven by SEM. Surprisingly, the inner part of the capsules contained big empty caverns (Fig. 2). ZA crystals were not directly observable in the PS matrix after cross sectioning.

Nevertheless, the oxygen originating from the carboxylic acid and the sulfat ester of the ZA was detected by ESCA. The load of ZA in the microcapsules was about 3% (w/w). PHA coatings containing the loaded PS microcapsules showed a constant release of ZA over 5 days in highly purified water. Thereby, a permanent presence of ZA at the coating surface is theoretically maintained in order to avoid biofilm formation.

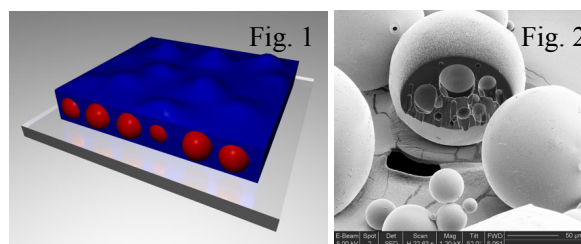


Fig. 1: Scheme of the PHA coating containing microcapsules on a glass substrate; Fig. 2: REM image of a cross section of a microcapsule.

DISCUSSION & CONCLUSIONS: Principally, PS microcapsules allow controlled release of the highly water soluble ZA into aqueous environments over a few days. The presence of the ZA at the surface of PHA coatings should repulse microorganisms and protect the biocompatible material from unwanted settlement. Experiments to proof this antifouling effect are the topic of current experiments.

REFERENCES: Zinn M. et al. *Environmentally Acceptable Control of Microbial Biofilms*. In: *Biofilms: Recent Advances in their Study and Control* (Ed. Evans L.V. Harwood) Academic Publishers, 2000.