

INFLUENCE OF SUBCRITICAL CARBON DIOXIDE ON BIODEGRADABLE POLYMERS

F. Maspero¹, K. Ruffieux^{1,2}, E. Wintermantel¹

¹ *Biocompatible Materials Science and Engineering, ETH-Zürich, Wagistrasse 23, CH-8952 Schlieren*, ² *Degradable Solutions AG, Wagistrasse 23, CH-8952 Schlieren*, ³ *Zentralinstitut für Medizintechnik der TU München, Boltzmannstrasse 15, D-85748 Garching*

INTRODUCTION: Gaseous carbon dioxide in the subcritical region ($T=21^{\circ}\text{C}$, $P=0-60$ bar) can be used as plasticizer or solvent for biodegradable polymers like polylactide and poly(lactide-co-glycolide). Due to its high solubility and its good diffusivity, gaseous carbon dioxide has been applied as physical foaming agent [1], to reduce the processing temperature for injection molding [2] and for manufacturing of open porous structures [3]. Thanks to its biocompatible character, traces of sorbed carbon dioxide present in the polymer matrix do not have to be removed by later purification steps before implantation.

This communication presents the characterization of the solubility and the diffusion kinetics of subcritical carbon dioxide in two different poly(lactide-co-glycolide) copolymer. The influence of the sorbed CO_2 molecules on the chemical structure of the polymers and on the glass transition temperature are discussed. Finally, some potential applications for gaseous CO_2 in the field of scaffold preparation are presented.

METHODS: For the characterization of the subcritical CO_2 -polymer system, poly(d,l-lactide-co-glycolide) (PLGA 85:15 and PLGA 50:50) plates (thickness: 150-450 μm) were used. Sorption isotherm experiments were performed using a high-pressure microbalance. Chemical structure of macromolecules exposed to subcritical CO_2 was investigated with FTIR spectroscopy. Phase transitions of the polymers were characterized using differential scanning calorimetry (DSC).

RESULTS, DISCUSSION & CONCLUSIONS:

Fundamental CO_2 anti-symmetric stretch vibrations absorption band at 2340 cm^{-1} , as well as absorption bands at 3590 and 3700 cm^{-1} , also attributed to CO_2 vibrations, are visible on FTIR spectra for samples containing sorbed CO_2 molecules. Gravimetric measurements carried out simultaneously to FTIR measurements permit to find a correlation between the intensity of the absorption bands and the weight fraction of sorbed

CO_2 . As CO_2 molecules desorb, the intensity of the bands decreases. After complete desorption, the entire FTIR spectra are similar to spectra of polymer non-exposed to CO_2 . This fact tends to confirm that no irreversible process occurs during the sorption.

DSC measurements on PLGA 85:15 and PLGA 50:50 permit to determine the influence of sorbed molecules on the glass transition temperature T_g . As the weight fraction of CO_2 in the polymer increases, T_g decreases. During sorption isotherm experiments between 20bar and 55bar, the glass transition temperatures of both PLGA 50:50 ($T_g: 55^{\circ}\text{C}$) and PLGA 85:15 ($T_g: 59^{\circ}\text{C}$) drop below room temperature. The experimental results can be fitted with the Flory's model for sorption isotherm of rubbery polymers. Diffusion coefficients have been found to depend on the PLGA composition.

The knowledge about the diffusion coefficient and of the dependency of T_g on the CO_2 weight ratio allows optimization of CO_2 -processing of degradable polymers. As potential application of CO_2 -processing, the manufacturing of carriers for drug release system will be shown.

REFERENCES: ¹ Mooney D.J. et al., *Biomaterials*, 1996, 17(14), 1417-1422. ² Seibt S., Thesis, Institut für Kunststoffverarbeitung an der RWTH Aachen, 1996 ³ Maspero F., et al. *Proceedings of the 6th World Biomaterials Congress*, 2000, Hawaii, USA.