"Enhancing Pulmonary Delivery via the Marangoni Effect"

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Abstract:
When formulated with surfactants, aerosols for pulmonary drug delivery have the potential to overcome aerodynamic limitations in the treatment of obstructive lung diseases such as cystic fibrosis. Transient Maragoni flows established on the airway surface liquid (ASL) by the added surfactant upon aerosol deposition can convect drug laterally from the point of deposition and around/over disease-associated mucus plaques. We have used a combination of aerosol droplet deposition experiments with mock systems (entangled polymer and porcine gastric mucin solution subphases mimicking the ASL, fluorophores mimicking drugs, multiple surfactant species) and numerical transport simulations (via COMSOL) to examine the competing roles of surfactant dissolution, diffusion and transient Marangoni convection fluxes in determining the extent of drug spreading. Large dissolution and diffusion fluxes lead to significant net drug transport, but poor spreading while small dissolution and diffusion fluxes lead to poor drug transport and poor spreading; extensive drug spreading occurs when dissolution and diffusion fluxes are similar in magnitude to the transient Marangoni convection flux. Several combinations of mock subphases, surfactants, and mock drugs will be discussed along with implications for delivery via both liquid and solid aerosols.

Bio:
Todd M. Przybycien, PhD, Professor of Chemical and Biological Engineering at Rensselaer Polytechnic Institute, received undergraduate degrees in chemical engineering and in chemistry from Washington University in St. Louis and Masters and PhD degrees in chemical engineering with a minor in biology from Caltech. Todd started his professional career with Monsanto Agricultural Company where he worked in bioprocess development for about two years. He then launched his academic career at Rensselaer Polytechnic Institute, where he worked for eight years, followed by another twenty years at Carnegie Mellon, where he was a faculty member in the Chemical Engineering Department and the Founding Head of the Biomedical Engineering Department. At Carnegie Mellon he also served two one-year, elected terms as chair of the Faculty Senate. In Fall 2018, he returned to RPI. Todd has authored over 75 technical publications in chemical engineering and biotechnology, has been awarded three patents and is a consultant to the biopharmaceutical and biotechnology industry. He has taught introductory courses in chemical engineering and biomedical engineering as well as advanced courses in thermodynamics, transport phenomena, interfacial phenomena, biotechnology and biomedical systems modeling. He is active in the American Chemical Society, the American Institute of Chemical Engineers, and the Society for Biological Engineering, and has held elected and appointed leadership positions in each organization. He has been recognized with a Career Award from the National Science Foundation, an Early Career Award from the faculty of Rensselaer, a Camille Dreyfus Teacher-Scholar Award from the Dreyfus Foundation and has been named a fellow of the American Chemical Society, the American Institute of Chemical Engineers and the American Institute of Medical and Biological Engineering.

Todd's primary research interests are in the areas of biopharmaceutical processing (focusing on bioseparations) and drug delivery. He has developed and used spectroscopic and biophysical tools to

establish structure-function-processing relationships for pharmaceutical proteins. Current work includes developing next-generation affinity chromatography media with enhanced selectivity and robustness, developing continuous precipitation-based separation processes, exploring how systematic and stochastic uncertainty propagates in downstream processes and new approaches to process analytical technology, especially for rapid adventitious agent detection. Current drug delivery work includes surfactant-enhanced pulmonary drug delivery and PEGylated protein delivery from depot/microsphere delivery devices.