Selective Sorbent Polymers for Capturing Toxic Chemotherapy Drugs in the Body

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Cancer is rapidly becoming the leading cause of death in most developed nations. Chemotherapy plays a critical role in helping patients fight cancer. Despite the effort to develop more targeted and personalized cancer chemotherapy drugs, the dosing of the chemotherapy drug is limited by toxic side effects. More than 90% of injected chemotherapy drugs, regardless of injected amount, bypasses the tumor, circulates throughout the body, and causes toxicities at distant locations.

There is no existing method to remove untrapped chemotherapy drugs in the body. In this context of reducing toxicities of untrapped chemotherapy drugs, we have designed a new biomedical device to selectively capture untrapped toxic chemotherapy drugs downstream of the tumor while injecting the chemotherapy drug upstream of the tumor. Successful development of such biomedical devices heavily relies on the design of highly selective sorbent polymers for targeting chemotherapy drugs in the body. In this study, we aim to design selective sorbent polymers for effective drug capture by understanding the mechanisms of drug capturing in these polymers.

We used doxorubicin, the most widely studied and effective chemotherapy drug for various cancers, as a model drug. We hypothesized two capturing factors, (1) electrostatic interaction between positively charged doxorubicin and oppositely charged polymers and (2) readily available empty voids in polymers. To test our hypotheses, we designed a library of crosslinked charged polymers with varying Ion Exchange Capacity (IEC, a measure of charge group concentration) and water uptake (a measure of the available void (i.e., free volume) in the polymer) using ionic block (2-acrylamido-2-methyl-1-propanesulfonic acid, AMPS) and neutral mechanical block (poly(ethylene glycol) diacrylate, PEGDA). We performed drug sorption and desorption experiments in the crosslinked AMPS-PEGDA polymers to characterize drug binding capacity, drug solubilities, and drug diffusivities at varying drug concentrations to identify the mechanism for effective drug capture. As Ion Exchange Capacity (IEC) and water uptake increases, the binding capacity in the polymer increases, whereas drug diffusivities and drug solubilities increase. Doxorubicin sorption and desorption experiments suggest IEC is the governing factor in the total amount of sorbed drug, whereas water uptake determines how fast the drug is sorbed or desorbed. The mechanism studied here will serve as a blueprint for designing selective sorbent polymers to capture toxic chemotherapy drugs in the body.