Selective inhibitors of microbial sulfate reduction (and beyond): High-throughput approaches for engineering geomicrobial ecosystems and characterizing microbial niche space

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The selective perturbation of complex microbial ecosystems to predictably influence outcomes in engineered and industrial environments remains a grand challenge for geomicrobiology. In some industrial ecosystems, such as oil reservoirs, sulfate reducing microorganisms (SRM) produce hydrogen sulfide which is toxic, explosive and corrosive. Current strategies to selectively inhibit sulfidogenesis are based on non-specific biocide treatments, bio-competitive exclusion by alternative electron acceptors or sulfate-analogs which are competitive inhibitors or futile/alternative substrates of the sulfate reduction pathway. Despite the economic cost of sulfidogenesis, there has been minimal exploration of the chemical space of possible inhibitory compounds, and very little work has quantitatively assessed the selectivity of putative souring treatments. We have developed a high-throughput screening strategy to target SRM, quantitatively ranked the selectivity and potency of hundreds of compounds and identified previously unrecognized SRM selective inhibitors and synergistic interactions between inhibitors. The high-throughput (HT) approach we present can be readily applied to target SRM in diverse environments and more broadly, could be used to identify and quantify the potency and selectivity of inhibitors of a variety of microbial metabolisms. Our findings and approach are relevant for engineering environmental ecosystems and also to understand the role of natural gradients in shaping microbial niche space.