Despite its reputation as a foul-smelling and toxic pollutant, H₂S is a vital biological signaling agent, and it is of interest as a therapeutic for a variety of diseases and conditions. We focus on developing new small molecules, polymers, and supramolecular materials for the delivery of hydrogen sulfide (H₂S). The majority of biological studies on this gasotransmitter have been carried out with systemically administered small molecule H₂S donors, which have little tissue specificity, fast release, and the potential for off-target effects. We address these shortcomings by developing new H₂S-releasing small molecules with controllable triggers and release kinetics. These small molecules are then incorporated into new materials, which can offer localized H₂S delivery with tunable kinetics. Our platforms include soluble polymers and peptide-based gels designed to release therapeutically relevant concentrations of H₂S with controllable kinetics.