PRF # 57379-DNI4
Desulfurization of crude oil by fluorous extraction
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Our PRF put forth a new approach to hydrodesulfurization of crude oil using fluorous extraction. The key to the success of this work is the development of selective chemistries to append fluorous tags to sulfur containing molecules such that they can be sequestered from the oil and partition into perfluorocarbon. In the past year, we have 1) explored using the branched fluorous tags prepared in year 1 for extraction of thiols into the fluorous phase and 2) investigated aryl-aryl interactions as a means to non-covalently tag thia-aromatics.

1) Using fluorous tags to partition thiols into perfluorocarbons

In the first year of the award, we devised an efficient route to biocompatible branched fluorous tags that can have a variety of functionality attached (Figure 1A). This work was published late last year (*Org. Lett.* **2018**, *20*, 6850). We showcased the efficiency of the branched tags compared to linear fluorous tags by the synthesis of porphyrin dyes containing either 4 C_8F_{17} (**1**) chains or 4 branched chains (**2**). Using the standard fluorous partition of toluene vs. perfluoromethyl cyclohexane, it is evident that the branched fluorous chains lead to superior fluorous solubility (Figure 1B). Next, we looked to employ the thiol-containing branched fluorous tag **4** to remove model thia contaminant **3** from organic solvent. Using the same mixture of toluene vs. perfluoromethyl cyclohexane, we could obtain one phase upon heating to the upper consolute temperature of 89 °C. Fluorous thiol **4** started in the perfluoromethyl cyclohexane and model disulfide (**3**) started in the toluene. After heating, a mixture of mixed disulfide **5** and fluorous disulfide **6** was obtained in the perfluoromethyl cyclohexane. Thus, we can preferentially partition sulfur-containing compounds into the fluorous phase; however, the propensity to form fluorous disulfide **6** remains a limitation of this approach.

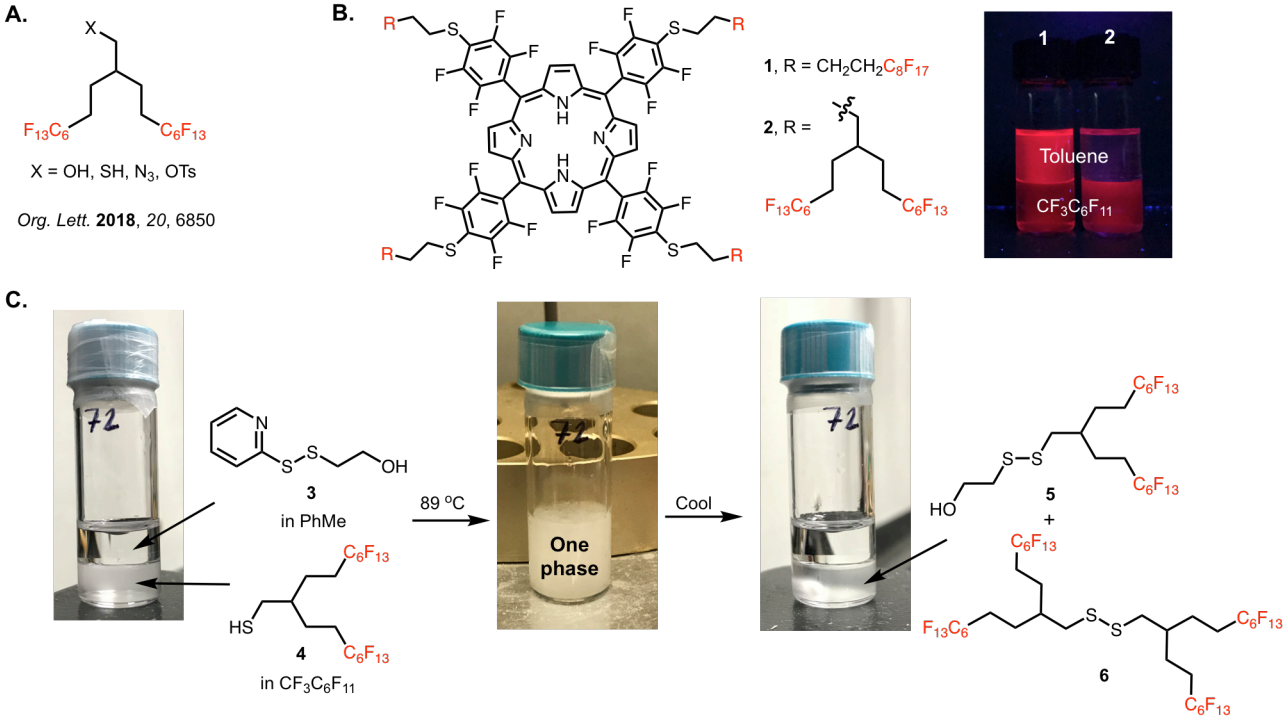
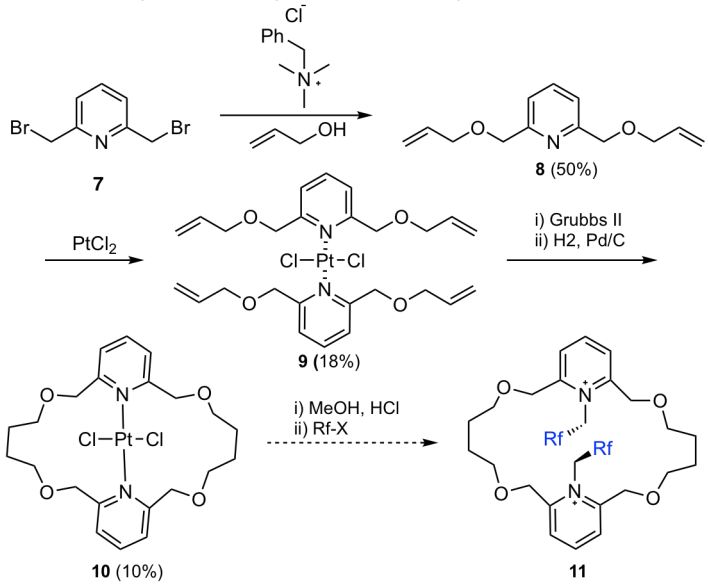


Figure 1. (A) Work from last reporting period regarding the efficient synthesis of branched biocompatible chains. (B) Fluorous porphyrins employed to evaluate the ability for the branched fluorous tags to sequester compounds into perfluorocarbon. (C) Model system for the use of the branched fluorous thiol to partition thiol contaminants into perfluorocarbon after heating above the upper consolute temperature.

2) Aryl-aryl interactions as a means to non-covalently tag thia-aromatics.

The final aim of our proposal explores non-covalent interactions to tag thia-aromatics. The investigation of the effect of cation-π interaction between positively-charged amine-containing heterocycles (e.g. pyridines, quinolines) and sulfur-containing heterocycles was initiated with the synthesis of the pyridinium host (Scheme 1). 1,3-Dibromomethylpyridine **7** was alkylated with allyl alcohol to produce **8** which was then dimerized using a platinum(II) chloride template to form **9**. The templated dimer was then primed for olefin metathesis and macrocycle formation which was performed using the Grubbs-Hoveyda Generation II catalyst followed by hydrogenation to saturate the hydrocarbon chains of the linker units of the host molecule and result in platinum bound host **10**. Decomplexation of the platinum in acidic conditions followed by alkylation would result in the final pyridinium structure **11**. Further optimization of this synthetic strategy will allow its expansion to quinolinium hosts that are expected to interact even stronger with sulfur-containing aromatic compounds via cation-π interactions.

Scheme 1: Synthesis of pyridinium macrocycle



Impact

Through support of the ACS PRF DNI grant, we have successfully developed an efficient approach to biocompatible branched fluorous chains that can be used for a wide variety of applications. Here we've shown that these can facilitate superior solubility in the fluorous phase, allowing for extraction of tagged species from organic mixtures but we expect these to tags to have broad applicability to chemists, chemical biologists, and materials scientists. The host-guest chemistry we will be continuing on, looking at a variety of cyclophane structures to determine the scope of binding affinities with different aromatics.

Students and postdocs that have been funded by the ACS PRF over the past two years have shown enormous scientific and professional growth and maturity. These projects have been a venue for learning synthetic chemistry, assay design, photophysical characterization, and binding affinity measurements. Students have also learned how to compile their results into poster and oral presentations as well as publications. Thank you for supporting early career chemists.