Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Electronic Supplementary Information

Contrasting reactions of hydrated electron and formate radical with 2-thio analogues of Cytosine and Uracil

Kavanal P. Prasanthkumar,[a*] Juan R. Alvarez-Idaboy,[b] Pavitra V. Kumar,[c] Beena G. Singh,[c*] and K. Indira Priyadarsini [c]

[a.] *Department of Chemistry, Government Engineering College, Thrissur 680 009 India*
[b.] *Departamento de Física y Química Teórica, Facultad de Química, Universidad Nacional Autónoma de México, México D. F., 04510, México.*
[c.] *Radiation and Photochemistry Division, Chemistry Group, Bhabha Atomic Research Centre, Mumbai 400085, India*

In our calculations it was found that, the H-abstraction mechanism remains much more favored from the thiol tautomer (represented as **TC1**) of 2-thiocytosine than the H-abstraction from the thionine form (i.e. **TC**). The **TC1** species upon H-abstraction gave **TC(S)•**, the latter undergo subsequent dimerization/recombination reactions. We found that, the dimerization of **TC(S)•** with another neutral **TC** molecule (i.e. (**TC(S)•** + **TC** → **TC_{dim}•**) is responsible for the transient species observed in the formate radical reactions of **TC**. Also, we have cited comparable reaction mechanisms in order to account for the transient species observed in the formate radical reactions of 2-thiouracil (**TU**).

Indeed, one reviewer has doubted the use of **TC1** and **TU1** as the starting point for the dimerization/recombination reactions (for e.g. **TC1** → **TC(S)•** → **TC_{dim}•**) and has demanded us to study the energy barrier between the tautomeric forms **TC** and **TC1** (and between **TU** and **TU1**). We know that, keto ↔ enol tautomerism (or thionine ↔ thiol tautomerism in thio compounds) occurs in protic solvents (typically in water) assisted by solvent exchangeable protons in acid or base catalyzed processes and are characterized by very high rate constants. Therefore, there is no way to isolate different tautomers experimentally. Due to this rapid inter conversion, tautomers are generally considered to be the same chemical species. Similarly, there exist limitations in studying the PES of tautomerization reaction theoretically.

The major problem in modelling the tautomerization reaction is the determination of accurate proton solvation in the transition state and is a difficult task using current quantum chemical methods. Herein, we have made an attempt (and of course not a fool proof method) to minimize this difficulty by explicitly adding two water molecules in the conversions of **TC** → **TC1** and **TU** → **TU1**. The results of modelling studies that we have performed at CBS-QB3//M06-2X/6-311+G(d,p) using SMD solvation are given in the following Fig.S1.

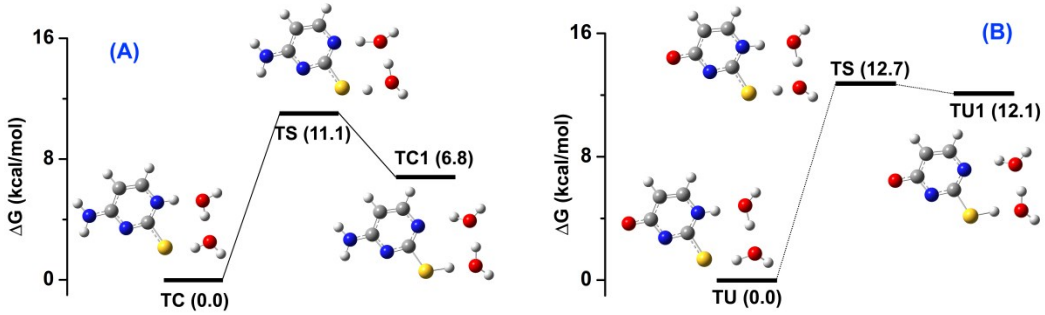

Fig.S1. Energy profiles obtained for the thionine ↔ thiol tautomerization of (**A**) **TC** and (**B**) **TU** modelled at CBS-QB3//M06-2X/6-311+G(d,p) level using SMD solvation.

However, we got reasonable upper limit values of Gibbs energy for both **TC** and **TU** (11.1 kcal/mol for **TC** and 12.7 kcal/mol for **TU**) tautomerizations. Nevertheless, the upper limit energy values no longer imply that there is any actual existence of thiol forms in solution for both thio compounds.

It should be noted that, keto ↔ enol tautomerization in acetone demonstrate a *classical example* for, how the presence of enol form is important in the accurate description of mechanisms of certain important reactions of so called keto compounds. The equilibrium constant, K = [enol]/[keto] ≈ 1.3×10^{-8}, which corresponds to Gibbs energy of 10.7 kcal/mol, therefore the keto

form tremendously predominates at equilibrium. Nonetheless, the enol form is so important for certain reactions. For example, the nucleophilic reactivity of carbonyl compounds in acidic solution is due to the presence of the enol tautomer. In other words, the equilibrium constant is quite small for monocarbonyl compounds, but the presence of the enol form permits reactions that do not occur from the carbonyl form. (Reference: Francis A. Carey, Richard J. Sundberg Chapter 6 “Carbanions and Other Carbon Nucleophiles Advanced Organic Chemistry 5th edition Part A: Structure and Mechanisms”).

Obviously in our case, the calculated equilibrium constant (K) favoring the S-H tautomer (thiol form) is much larger for **TC** ($K = 3.6 \times 10^{-4}$) while the K value of **TU** (7.7×10^{-9}) is comparable to the *classic example* presented in the above mentioned textbook. So we assured that, our supposition of using **TC1** and **TU1** as the starting point is reasonable for the dimerization reactions to account for the pulse radiolysis experimental results.