

### **Description of Additional Supplementary Files**

File Name: Supplementary Movie 1

Description: Initial proton transfer from S267 to N $\epsilon$  His408 and relevant nucleophilic attack in acylation.

File Name: Supplementary Movie 2

Description: Proton transfer from N $\epsilon$  His408 to create CI and leaving group in acylation.

File Name: Supplementary Movie 3

Description: Initial proton transfer from hydrolytic water and relevant nucleophilic attack on CI in deacylation.

File Name: Supplementary Movie 4

Description: Proton transfer from N $\epsilon$  His408 to O of CI in deacylation.