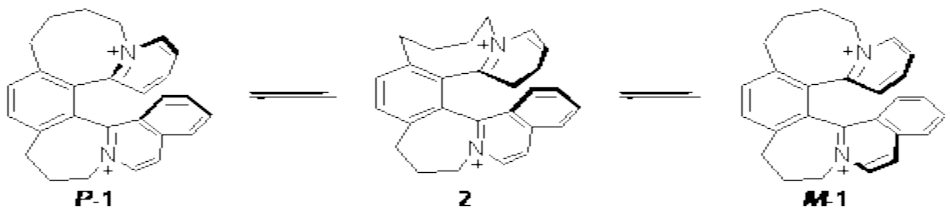
[6]SADDLEQUAT – THE RUBER GLOVE INVERSION

In 1955 Mislow[1] discussed the possibility of enatiomers interchanging via a path that was entirely chiral, never passing through an achiral structure. His analogy is the inversion of a rubber glove, taking a right hand rubber glove and pulling it inside out creates a left hand glove (its mirror image) but never passing through an achiral glove. Well, now a helicene with this type of stereochemistry has been developed, with a stable chiral intermediate.[2]

Helicenes typically interchange ($P \rightarrow M \rightarrow P$) through an achiral saddle-like structure. But larger helicenes can have high-lying intermediates along this pathway. Helquat ***P-1*** interchanges to ***M*-1**through the intermediate **2**, which is an achiral structure and can be isolated.



Computations at B3LYP/def2-TZVP//PBE/def2-SV(P) with dispersion corrections (and PCM simulating DMSO) of the inversion process identified a number of intermediates and transition states along the stereoinversion pathway.

The intermediate **2** lies 18.4 kJ mol^{-1} above **1**. These structures are shown in Figure 1. The highest lying TS between **2** and ***P*-1** (labeled **TSP** in Figure 1) is 119 kJ mol^{-1} above **2**. The highest lying TS on the path from **2** to ***M*-1** (labeled **TSM** in Figure 1) is 138 kJ mol^{-1} above **2**. Note that going from **2** to ***P*-1** is not the mirror image path of going from **2** to ***M*-1**.

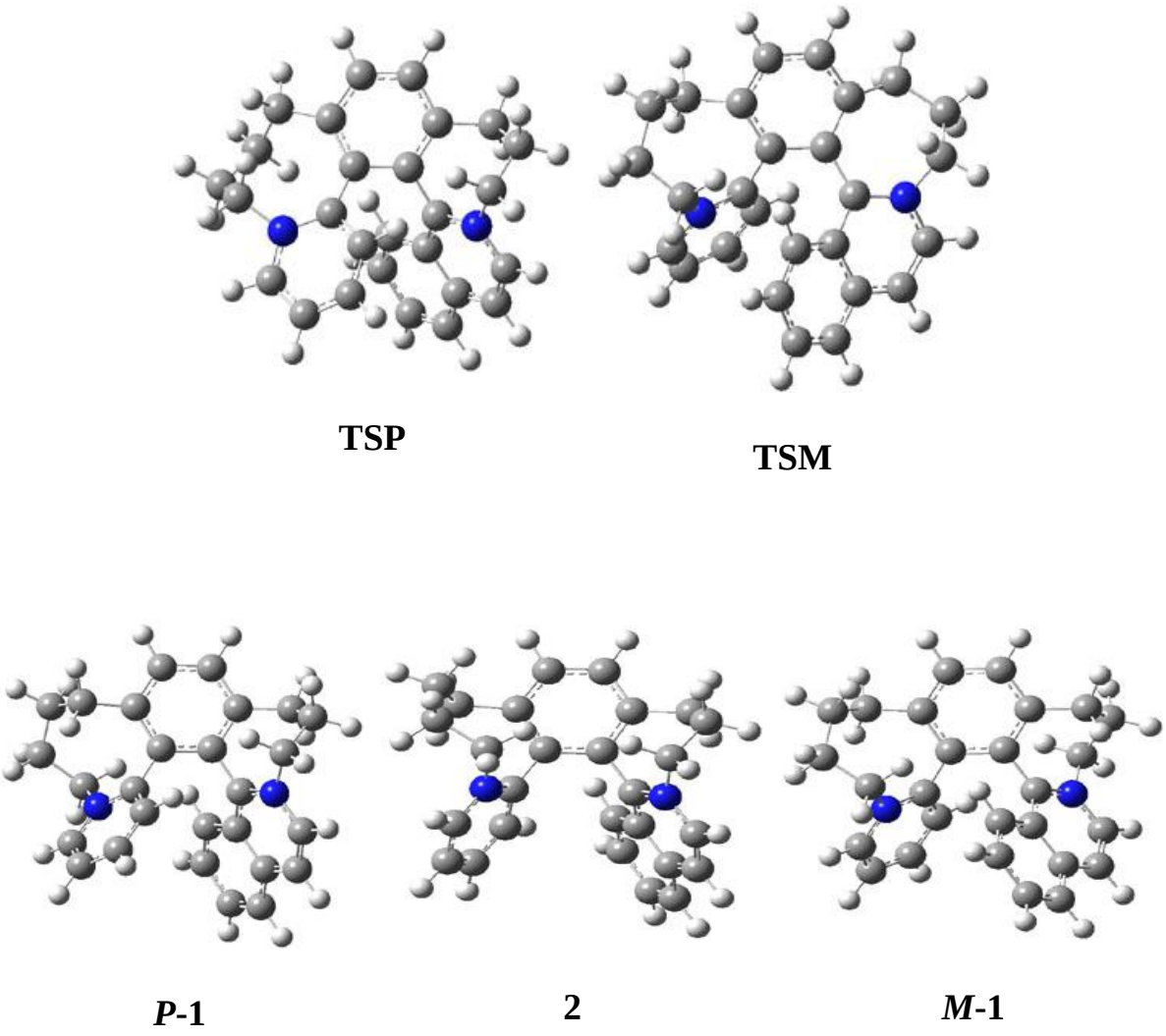


Figure 1. Optimized structures of **1**, **2**, and the highest transition states interconverting them.

Heating racemic **2** and following the conversion to **1** with NMR gives the activation barrier of 119 kJ mol^{-1}, in excellent agreement with the computation.

Racemic **2** was resolved through differential crystallization and its x-ray structure indicates it is (+)-[S_a,R_a]. Heating it does give just ***P*-1**, as predicted by the computations. Then heating ***P*-1** to 180 °C does racemize it, with an experimental barrier of 157.7 kJ mol^{-1}. The computations predict a barrier of 156.6 kJ mol^{-1}, again in fine agreement with experiment. Overall, a nice piece showing experiment and computation working together to provide an understanding of an interesting chemical system!

Source: http://comporgchem.com/blog/?p=1849