Thermal and Photo-Driven Switching of Azobenzene Derivatives on Graphite: Anomalous One-Dimensional Cascade Effect

Hariom Birla[1], Showkat H. Mir[2], Khushboo Yadav[1], Thomas Halbritter[3], Alexander Heckel[3], Jayant K. Singh[4] and Thiruvancheril G. Gopakumar[1,*]

[1]*Department of Chemistry, Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh, 208016, India*
[2]*Department of Physics, University of Kashmir, Srinagar, 190006, Jammu and Kashmir, India*
[3]*Institute for Organic Chemistry and Chemical Biology, Goethe-University Frankfurt, Max-von-Laue-Str. 9, 60438, Frankfurt, Germany*
[4]*Department of Chemical Engineering, Indian Institute of Technology Kanpur, Kanpur, 208016, India*

Presenting author's e-mail: hbirla@iitk.ac.in

Exploiting cooperative switching mechanisms enables precise control over the responsiveness of molecular films to external stimuli, offering pathways to tailor reaction directionality and engineer innovative nanostructures. In this study, we report a one-dimensional (1D) cascade phenomenon in the thermal- and photo-induced switching of azobenzene derivatives adsorbed on a graphite surface. Upon exposure to heat or light, the molecules undergo reversible trans–cis isomerization along a specific lattice direction within the molecular assembly. Using atomic force microscopy (AFM) and scanning tunneling microscopy (STM), we investigate this switching behavior at the molecular level and find that the cascade propagates preferentially along lattice directions with the strongest intermolecular interactions. Both theoretical modeling and experimental observations indicate that the cascade can extend to approximately 350 molecules under photo-activation and up to 530 molecules under thermal activation along a single lattice pathway.

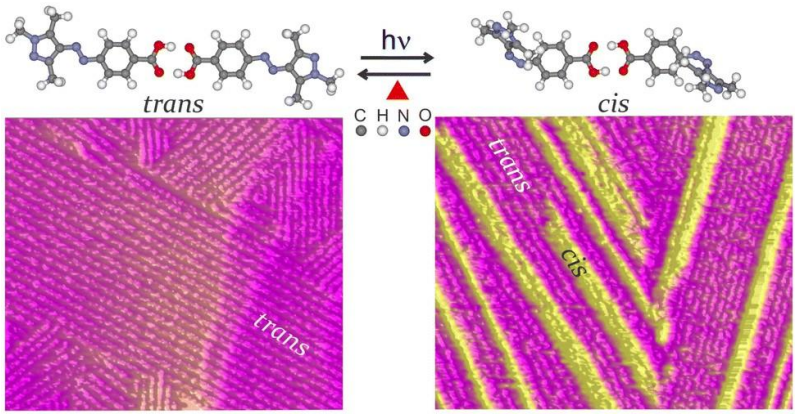

Figure 1. Top panel: optimized geometry of the hydrogen bonded dimer of *trans* and *cis* isomers of azobenzene molecule (AB). *Trans* isomer in the AB adlayer is switched to the *cis* isomer by photons and are switched back thermally. Lower left panel shows the AFM phase image of the *trans* dominant AB adlayer. Lower right panel shows the AFM phase image after illuminating the *trans* dominant AB adlayer. Yellow rod-like contrasts correspond to 1D chains of the *cis* isomer within the assembly of *trans* isomers (magenta).

Reference

[1] Birla H, et al. Chem. Sci. **16(15)**, 6325-6335 (2025).