

Near-infrared fluorophores based on electron-deficient fused quinodimethanes

Fluorescent dyes are substances that can glow under specific types of light. They are commonly used in modern medicine and biology, for example, to track drugs movement through the body or to detect cancer cells prior to surgery. However, most dyes currently used absorb and emit visible light, which cannot penetrate tissues deeply and can damage them. To overcome these limitations, scientists are developing dyes that emit light in the near-infrared (NIR) range—a type of low-energy light capable of safely passing through living tissues to provide clearer, deeper images in novel microscopic techniques. This project will focus on creating new fluorescent dyes that glow in the NIR range and can one day be used in medical diagnostics, research, and innovative technologies like biological sensors or dyes for highly precise microscopy. The goal is to design fluorescent organic molecules that are bright, highly stable, and water-soluble—an important feature for applications within the human body. What makes this project unique is the use of a special chemical structure called para-quinodimethane, which enables precise control over the color and brightness of the dyes.

The research team plans to develop three types of dye molecules, each with special chemical groups based on sulfur, phosphorus and carbon, that help regulate how the molecules interact with light and their chemical environment. The final molecules will be capable of attaching to proteins or other biological molecules, making them useful for visualizing specific targets such as cancer cells.

The project will be carried out in three steps. First, the investigator will create the basic dye structures and test how they absorb and emit light. Then, improved versions will be designed using theoretical calculations to design changes in the structure enhancing performance of emission and shift it deeper into the NIR range. Finally, the dyes will be modified to not only increase their water-solubility and compatible with biological systems, but also to introduce chemical "hooks" that can attach specific biological molecules to the dyes.

If successful, this project could lead to safer and more effective tools for doctors and scientists. The new dyes may help earlier disease detection, monitor how treatments work, and guide surgeries with greater precision. Beyond medicine, the results could also benefit the development of new materials in electronics. In the longer term, the knowledge gained will support future research in chemistry, materials science, and biotechnology.