# Development of Novel Energetic Compounds and Nanomaterials.

Prof. Michael Gozin

School of Chemistry, Faculty of Exact Sciences, Tel Aviv University, Tel Aviv, Israel. **E-mail**: cogozin@gmail.com

One of the successful strategies for the design of promising new energetic materials is incorporation of both fuel and oxidizer moieties into the same molecular structure. Therefore, during recent years, synthesis of various nitro-azole derivatives, as compounds with more balanced oxygen content, became very popular. In the frame of our work, a series of nitrogen-rich energetic materials (EMs), with improved sensitivity, thermostability, and very low toxicity, were synthesized on the basis of 3,5-diamino-1,2,4-triazole (DAT) and 1,2,4,5-tetrazine building blocks. Since DAT contains several nucleophilic reactive sites, obtaining selective reactivity and specific isomeric products with 1,2,4,5-tetrazine precursors is a challenging task. Our new solid propellants could be very good candidates for the development of solid-state gas generators for clean fire-extinguishing systems and for a broad range of other civil and defense applications that require the use of "green" and insensitive EMs.

In the second part of my talk, I will present a group of new energetic coordination nanomaterials based on functionalized graphene oxide sheets (FGS) that we designed, prepared and characterized. Graphene oxide was first functionalized with nitrogen-rich energetic ligands such as triaminoguanidine, and then the resulting FGS was coordinated with copper metal ions to form energetic nanomaterials with high thermostability and insensitivity to mechanical impact. This new type of insensitive energetic materials could be very useful as keyingredients in low-vulnerability solid propellants and in shaped charges of deep-well perforating guns (for oil and gas exploration).

**References**:

1. "Energetic isomers of 1,2,4,5-tetrazine-bis-1,2,4-triazoles with low toxicity", Shlomovich, A.; Pechersky, T.; Cohen, Adva; Yan, Qi-Long; Kosa, Monica; Petrutik, Natan; Tal, Noam; Aizikovich, Alexander; Gozin, Michael; *Dalton Trans.* (**2017**), 46(18), 5994-6002.

2. "A layered 2D triaminoguanidine-glyoxal polymer and its transition metal complexes as novel insensitive energetic nanomaterials", Yan, Qi-Long; Cohen, Adva; Chinnam, Ajay K.; Petrutik, Natan; Shlomovich, Avital; Burstein, Larisa; Gozin, Michael; *J. Materials Chem. A: Materials for Energy and Sustainability* (**2016**), 4(47), 18401-18408.

3. "Highly Thermostable and Insensitive Energetic Hybrid Coordination Polymers Based on Graphene Oxide-Cu(II) Complex", Cohen, Adva; Yang, Yuzhang; Yan, Qi-Long; Shlomovich, Avital; Petrutik, Natan; Burstein, Larisa; Pang, Si-Ping; Gozin, Michael; *Chem. Materials* (**2016**), 28(17), 6118-6126.

4. "Highly Insensitive and Thermostable Energetic Coordination Nanomaterials Based on Functionalized Graphene oxides", Yan, Qi-Long; Cohen, Adva; Petrutik, Natan; Shlomovich, Avital; Burstein, Larisa; Pang, Si-Ping; Gozin, Michael; *J. Materials Chem. A: Materials for Energy and Sustainability* (**2016**), 4(25), 9941-9948.

5. "Highly energetic compositions based on functionalized carbon nanomaterials", Yan, Qi-Long; Gozin, Michael; Zhao, Feng-Qi; Cohen, Adva; Pang, Si-Ping; *Nanoscale* (**2016**), 8(9), 4799-4851.