

**Experimental and Computational Studies on the Thermodynamic and Structural
Properties of a Maleic Anhydride Derivative:
1,2,4,5-cyclohexanetetracarboxylic dianhydride (HPMDA)**

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Maleic anhydride derivatives are among the compounds that constitute the monomeric units of stimuli-responsive polymers most referred to as *smart materials*.¹ These polyanhydrides have also been shown to present enormous potential in the development of drug delivery systems.² Acknowledging that the observed properties of a polymer are hugely determined by the properties of its monomers, the knowledge of the fundamental properties of the monomer molecule is crucial. For this work, currently in its mid stages, we are studying the structural and energetic properties of 1,2,4,5-cyclohexanetetracarboxylic dianhydride (HPMDA), a maleic anhydride derivative, by experimental methods in tandem with high-level computational studies.

The experimental part involved Differential Scanning Calorimetry (DSC), combustion calorimetry,³⁻⁴ Calvet microcalorimetry,⁵ and Knudsen effusion⁶ to, respectively, observe the thermal behavior of HPMDA, determine the standard ($p^\circ = 0.1$ MPa) molar enthalpy of combustion in the crystalline phase, $\Delta_c H_m^\circ(\text{cr})$, the standard molar enthalpy of sublimation, $\Delta_{\text{cr}}^g H_m^\circ$, and the temperature-vapor pressure dependence. These data led to the derivation of the standard molar enthalpy of formation of HPMDA in the crystalline phase, $\Delta_f H_m^\circ(\text{cr})$, and the standard molar enthalpy of formation in the gaseous phase, $\Delta_f H_m^\circ(\text{g})$. Moreover, the DSC thermograms revealed that HPMDA exhibits polymorphism. We are currently performing X-ray diffraction (XRD) studies and more DSC experiments to properly characterize HPMDA's polymorphic nature.

For the computational part, we are employing several methods at several levels of theory: methods at the DFT level,⁷⁻⁸ and high-level methods using variants of the G3 level⁹ and

the G4 level.¹⁰ This multi-level computational study led to the estimation of the gas-phase enthalpies of formation for each different levels of theory and thus allowed for a comparative evaluation of the results of the different computational methods. We are observing a very good agreement between our computational and experimental results.

Acknowledgments:

This work had the financial support of national funds, through FCT - Foundation for Science and Technology, Portugal, within the scope of the R&D project with reference UIDB/00081/2020. V.L.S.F thanks FCT and FCUP for the Program Contract established under the transition rule of Decree Law 57/2016, amended by Law 57/2017. In addition, VBS Cardenas thanks the Erasmus+: Erasmus Mundus programme of the European Union for his Erasmus Mundus scholarship under the framework of the Erasmus Mundus SERP+ Master (www.master-serp.eu).

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