Organic synthesis - applications in enzymatic studies, catalysis and surface modification

In a desire to explore various areas of synthetic organic chemistry, different projects have been carried out, and each of the four following chapters will describe the work carried out on each of them. The first three chapters are related in some extent and treat the synthesis and biochemical applications of (phospho)lipids, while the last chapter differs and deals with the synthesis and initial structural studies of a C3 symmetric phosphine oxide.

In the first chapter, a series of phospholipids have been synthesised in order to perform a short structure-activity relationship study of an enzyme, secretory phospholipase A2 (sPLA2), capable of hydrolysing phospholipids in the sn-2 position specifically. This enzyme is over-expressed in several types of cancer and is under evaluation as a potential trigger for drug release from a new generation of liposomal drug delivery systems. However, little is known about the steric and electronic requirements in the vicinity of the sn-2 position for an effective hydrolysis catalysed by the enzyme. Based on previous observations and on MD experiments, we developed a theory to predict and/or explain the activity of the enzyme on engineered phospholipids. According to our theory, two aspects of the enzyme-substrate interactions are primordial for an effective hydrolysis to occur: the formation of a constructive Michaelis-Menten complex, and access of water to the hydrolysis site. In order to verify this theory, the synthesised phospholipids were formulated as liposomes and the enzymatic activity was studied. Hydrolysis (or absence of hydrolysis) was monitored by MALDI-TOF-MS. The results observed in these experiments are compared to MD predictions and confirm them.

The second chapter deals with surface functionalization of liposomes. The copper mediated [3+2] azide-alkyne cycloaddition has been successfully applied for this purpose by different groups, but no general optimization has been developed for the reaction on functionalised liposomes. Since the reaction generally takes place between one functionality on the surface of the liposomes membrane and a functionality covalently linked to a coupling partner (such as small molecule, peptide, etc.), we investigated the efficiency of the reaction depending on the position of the functional groups (whether on the liposome or on the coupling partner). Our results indicate that the reaction is most efficient when the liposome carries the alkyne functionality rather than the azide. We also investigated and developed a novel selective method for functionalizing liposomes, which has not yet been reported in the literature, based on the reaction between propargyl-amine decorated liposomes and isothiocyanate derived coupling partners that results in a coupling via formation of an iminothiazolidine.

In the third chapter, the synthesis of sn-2 glyceryl 10,16-dihydroxyhexadecanoate is reported, in the context of the identification of the process of formation of the cutin polymer, one of the primary protective components of the epidermis of land plants. The enzyme responsible for the polymerization (CD1), as well as its substrate, has been identified, and the role of the enzyme has been demonstrated by its activity on the synthetic dihydroxyacylglycerol.

Finally, the last chapter differs greatly from the first three by its focus: a C3 symmetric phosphine oxide has been synthesised, which we intend to test, after reduction to the phosphin, as a ligand in organometallic catalysed reactions. The ultimate goal is to obtain enantioselectivity, introduced by the organization of aryl substituents around phosphorous in our ligand.

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