Study of polysaccharide-lipid interactions using molecular dynamics simulations, quantum chemical 13C NMR spectra computation and 13C solid-state NMR

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Résumé

Interactions between polysaccharides and lipids are now a vast field of study, of particular interest for the food and pharmaceutical industries. We know that amylose, an essentially linear polysaccharide composed of glucose residues linked in a [α 1→4] manner, can encapsulate small hydrophobic molecules, forming so-called V-helical complexes. However, to the best of our knowledge, no complex has been characterized with lipids bearing more than one acyl chain. Among the experimental methods used to characterize such structures, solid-state NMR has already proven to be an efficient tool, since heterogeneous samples can be characterized and the presence of different structures revealed. Theoretical approaches are also available to help characterize the three-dimensional structures of these complexes. Among them, numerous studies have been undertaken using all-atom molecular dynamics simulations. The behavior of folded amylose as well as the folding process have been characterized, in the presence and absence of guest molecules. In addition, the use of quantum mechanical methods now permits the study of the structural, electronic or spectroscopic properties of systems of this size. In particular, it has been shown that taking the dynamic properties of these complexes into account is required to accurately compute NMR spectra of amylose complexes. We present a study, combining experimental ssNMR spectra, molecular dynamics simulations and quantum chemical computation of NMR parameters that provides evidence of the formation of inclusion complexes of amylose containing lipids bearing multiple acyl chains. This study also yields structural information for these complexes. We first characterize the effect of unsaturation in the acyl chains, through the study of samples containing palmitic and oleic acids. We prove that inclusion complexes can be obtained in the presence of phostatidylcholines, and that the amount of complex formed depends on the presence or

*Intervenant

absence of unsaturated groups in the acyl chains. We then examine the formation of inclusion complexes obtained in the presence of lipids from the atypical cell walls of bacteria belonging to the order Corynebacteriales, *Corynebacterium glutamicum* and *Mycobacterium tuberculosis*. We demonstrate that inclusion complexes are formed in the presence of mycolic acids, trehalose monomycolates and dimycolates, Cgl lipids containing up to 4 acyl chains. Finally, we show evidence for the formation of inclusion complexes in the presence of phtiocerol dimycocerosate extracted from the Mtb cell wall and known to be a virulence factor of the bacillus.