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Virtual Issue: Carbohydrates in the 21st Century: Synthesis and Applications**

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Carbohydrates are the structurally most diverse of all naturally occurring organic molecules. As such they play many varied roles throughout nature, ranging from structural materials and energy sources, to complex information molecules responsible for the mediation of a wide range of cellular recognition and trafficking processes. Correspondingly, the chemistry of carbohydrates should have multifaceted applications throughout modern society. However, the structural complexity of these highly functionalised molecules, with their numerous hydroxyl groups, carbonyls, and multiple stereogenic centres, makes their synthetic manipulation at best protracted and, at worst, extremely difficult. Nonetheless modern synthetic chemistry continues to rise to meet the challenges posed by these highly polar and densely functionalised molecules. In this Virtual Issue, we highlight the combination of underpinning synthetic chemistry and the biological importance of carbohydrates, which together promise the development of future applications of carbohydrate-based materials as novel vaccines, adjuvants, anti-infectives, and diagnostics.

This Virtual Issue on "Carbohydrates in the 21st Century: Synthesis and Applications" highlights current research in the carbohydrate field in which synthesis underpins the development of novel sugar-based materials applied in medicine and diagnostics.

Firstly, as a demonstration of the power of modern organic synthesis, Mlynarski and co-workers (DOI: 10.1002/open.201500099) report the development of efficient one-step organocatalytic aldol reactions for the production of a range of higher carbon sugars, a class of important biomolecule found throughout nature, particularly in bacterial lipopolysaccharides (LPS). Continuing the theme of the synthetic chemistry of higher-carbon sugars in relation to bacterial LPS, Kosma and co-workers (DOI: 10.1002/open.201500126) report on the use of 3-iodo-Kdo (3-deoxy-D-*manno*-octulosonic acid) glycosyl fluorides with *N*-acetylglucosamine (GlcNAc) acceptors, and reveal that efficient stereoselective glycosylation processes, which avoid side reactions, can be achieved by the specific use of α-configured glycosyl acceptors.

Focussing on the synthesis of fungal capsular polysaccharide epitopes, Oscarson and co-workers (DOI: 10.1002/open.201500143) report on the development of a glucuronic-acid-containing trisaccharide building block, which can act both as a donor and acceptor, for the construction of vaccine candidates against the fungal pathogen *Cryptococcus neoformans*. Continuing the vaccine theme, Rendle and co-workers (DOI: 10.1002/open.201500149) report on attempts to develop new synthetic vaccine adjuvants by the glycosylation of three structurally similar triterpenoids to produce saponin mimics of the natural product QS-21, itself a highly potent adjuvant. Work detailed includes a study of the nanostructures formed when the product saponins were formulated with cholesterol and phospholipid, together with an investigation of immunostimulatory effects both in vitro and in vivo.

Titz and co-workers (DOI: 10.1002/open.201500162) report on a different approach to fight bacterial infection—combatting the Gram-negative pathogen *Pseudomonas aeruginosa* with carbohydrate derivatives. In their work, they develop mannose-based glycomimetic inhibitors of one of its lectins, LecB, which is important for bacterial adhesion and biofilm formation.

A considerable obstacle to the development of highly potent inhibitors of undesirable carbohydrate-mediated biological processes is the fact that protein-carbohydrate interactions are generally low affinity. Nature gets around this issue by using multivalent presentation of carbohydrate ligands, allowing tight and highly selective binding. Chemists can now also mimic these types of multivalent presentation to achieve high-affinity binding with exquisite selectivity. The three final papers in this Virtual Issue all focus on multivalent applications of carbohydrates.

In the 21st Century, we should expect increasingly diverse applications of carbohydrates and their mimics throughout biology, medicine, and materials science.

Pieters and co-workers publish two papers, which centre on multivalency. In the first (DOI:

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10.1002/open.201402171), like Titz and co-workers, they report studies against *Pseudomonas aeruginosa*, but they focus on inhibition of another adhesion lectin, LecA. Herein they report the synthesis of a new series of divalent ligands for LecA and report on their binding efficiencies. In their second paper (DOI: 10.1002/open.500006) they examine inhibitors of cholera toxin, which, as a key step in the infective process, binds to the intestinal surface via a well-known multivalent interaction. In this work they examine the relative efficiencies of tetra- and pentavalent inhibitors of this binding event.

Finally, my own group (DOI: 10.1002/open.201500109) reports on the facile preparation of gold nanoparticles decorated with complex bi-antennary *N*-glycans bearing α(2–6)-linked sialic acids at their termini, using oligosaccharides isolated from egg yolks. The multivalent presentation of these sialic acids allowed the development of a highly sensitive and selective gold-nanoparticle-based sensor for both influenza hemagglutinin and the influenza virus itself.

In the 21st Century, we should expect increasingly diverse applications of carbohydrates and their mimics throughout biology, medicine, and materials science. In this Virtual Issue of *ChemistryOpen*, we have perhaps had a sneak preview of just a few of the areas for future development and, hopefully, application.

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