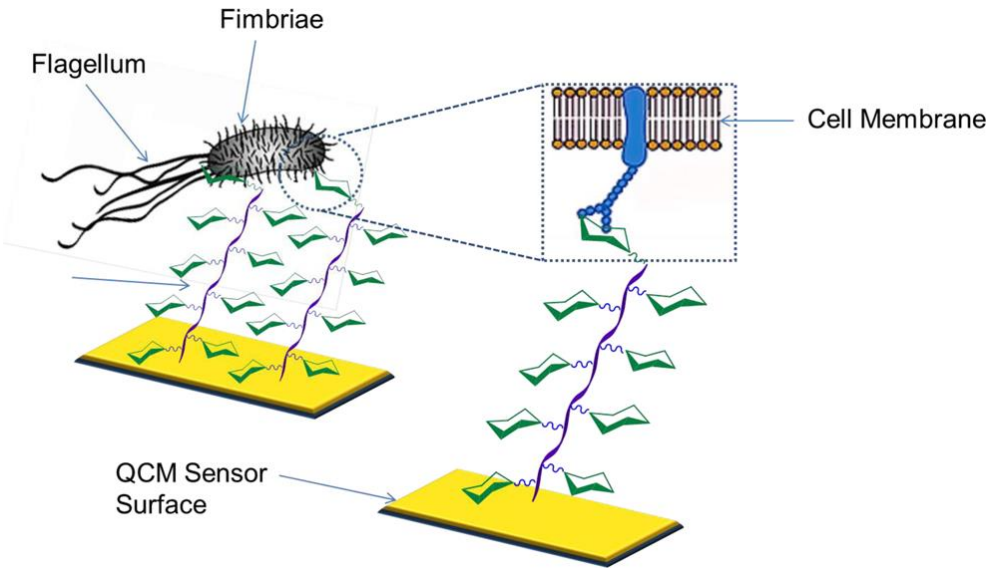
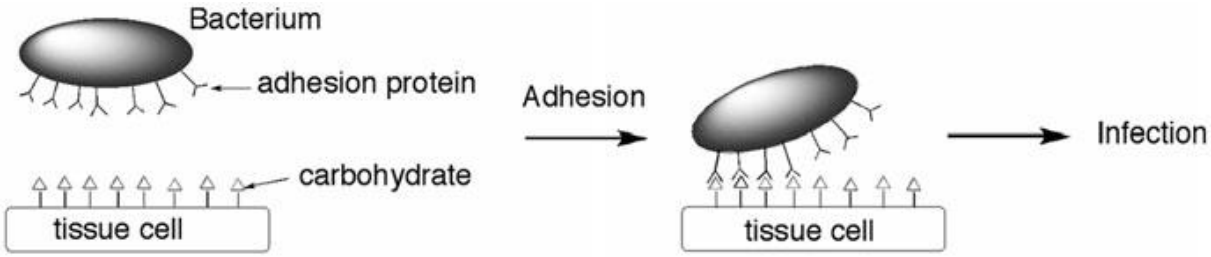
Simple summary on bacterial adhesion

Protein–carbohydrate interactions are involved in a wide variety of cellular recognition processes including cell growth regulation, differentiation and adhesion, the immune response, and viral or bacterial infections. A common way for bacteria to achieve adhesion is through their fimbriae which possess cellular lectins that can bind to complementary carbohydrates on the surface of the host tissues. [1]



Scheme 1: Schematic Representation of the Specific Interactions of Bacteria to Glycopolymers Immobilized on QCM-D Surface [1]



Scheme 2: The principle of bacterial adhesion as a prelude to infection. [2]

One should take into consideration the saltiness of the enviroment in which the bacteria adheres to the surface. For example the bacterial adhesion can be dependelt on the concerntration of NaCl and $CaCl_2$ in the solution. [1]

Bacteria adhere to rough surfaces more than to smooth ones. Even when the roughness is in nanoscale. Rough surfaces produce a bacterial growth in preferential directions. [3]

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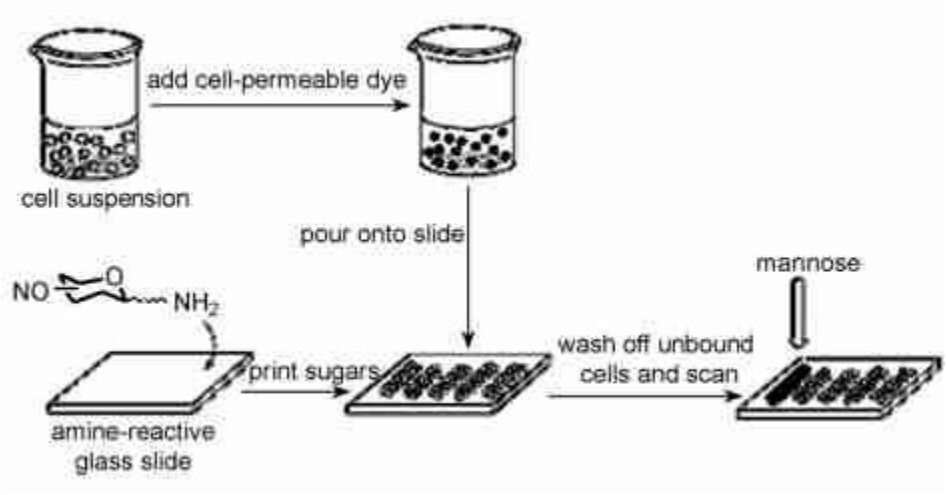
[1] „Study of Bacterial Adhesion on Different Glycopolymer Surfaces by Quartz Crystal Microbalance with Dissipation“ by Yinan Wang, Ravin Narain, and Yang Liu

[2] „Carbohydrate Mediated Bacterial Adhesion“ by Roland J. Pieters Ch 14 in „Bacterial Adhesion“ edited by Dirke Linke and Adrian Goldman

One possible way to catch cyanobacteria is to apply carbohydrate microarray analysis technique to catching cyanobacteria. Carbohydrate microarrays include glycan microarrays are used for analysis purposes to detect viruses, bacteria, antibodies etc. With glycan microarrays one can detect with high precicion and quickly the presence of a disease. Usually they are used not only to detect bacteria itself but a specific glycoconjugates that bacteria synthesis when reproducing.

Glycan microarrays have very many applications in detecting different substances. [4]



Scheme 3: Carbohydrate microarray for detecting E. coli [5]

Analysis of a solution is usually as follows. Usually the microarray is printed on a glass substrate. The solution containing the substance that we want to study is dipped on the arrays. Then after washing the array is analysed with another method.

Carbohydrate array fabrication examples

An example of a step by step glycoaarray analysis from start to finish can be found in reference [6]. More techniques on production can be found in [7], [8].

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[3] „Influence of the Nano-micro Structure of the Surface on Bacterial Adhesion“ by Carolina Díaz, María Cecilia Cortizo, Patricia Laura Schilardi, Sandra Gabriela Gómez de Saravia, Mónica Alicia Fernández Lorenzo de Mele

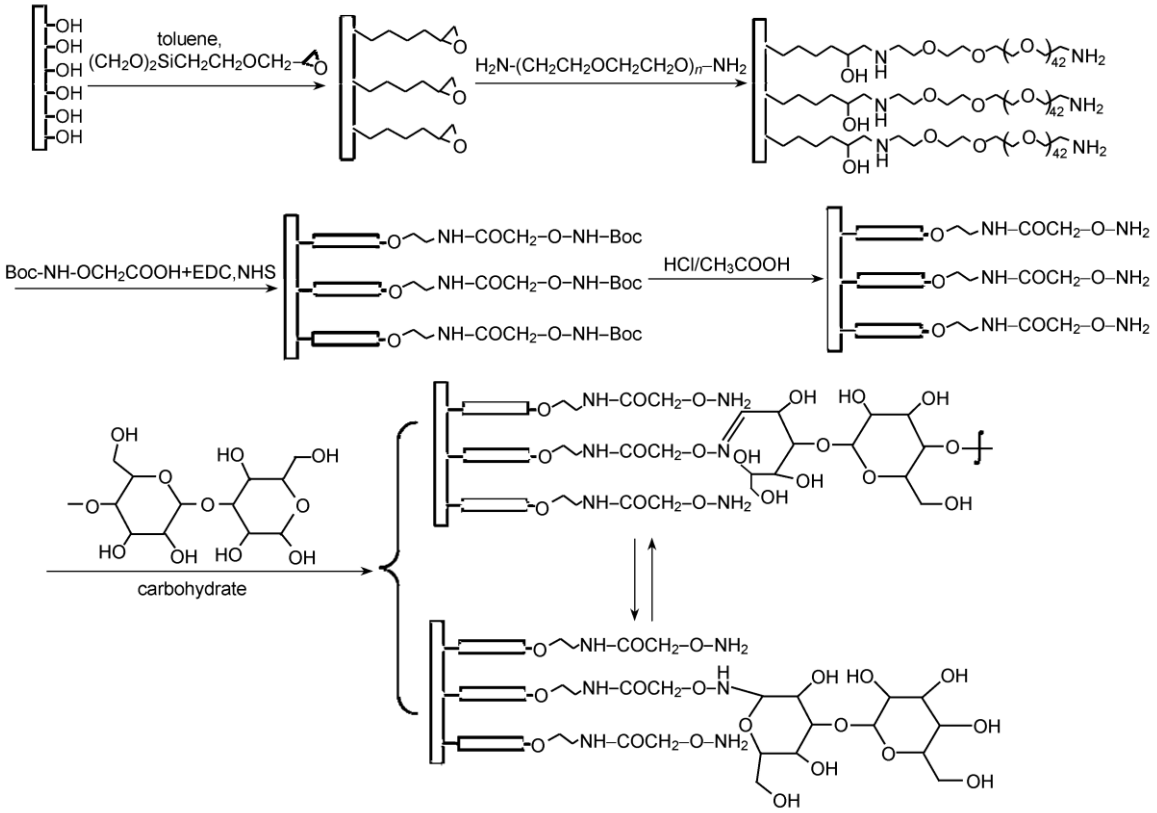
[4] „Glycan microarrays: new angles and new strategies“ by Boglarka Donczo, Janos Kerekgyarto, Zoltan Szurmai and Andras Guttman

[5] Disney M D , Seeberger P H. Chemistry & Biology , 2004 , 11 : 1701 –1707

[6] „Glycan Microarrays“ by Xuezheng Song, Jamie Heimburg-Molinaro, David F. Smith, and Richard D. Cummings, Ch 11 in „Chemical Genomics and Proteomics“ ed: Edward D. Sanders

[7] „Carbohydrate Microarrays: Survey of Fabrication Techniques“ by ADRIAN S. CULF, IROSLAVA CUPERLOVIC-CULF, RODNEY J. OUELLETTE

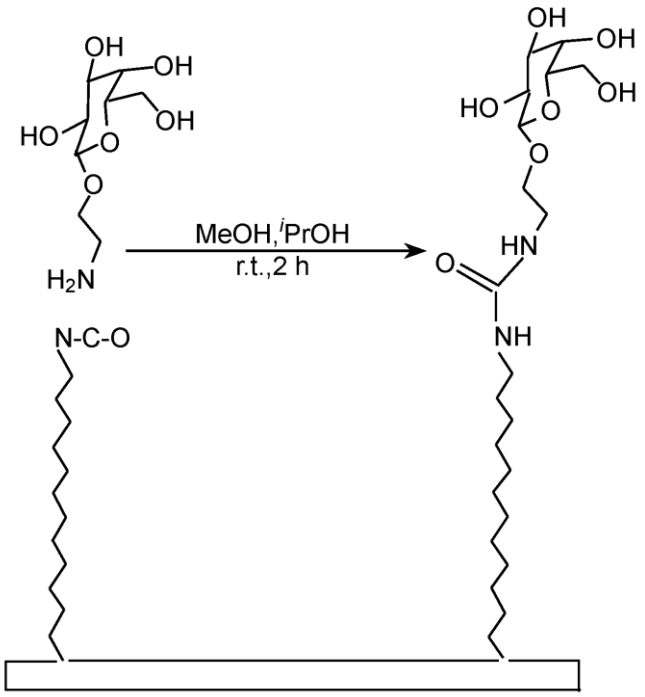
The overall fabrication techniques are contact and non-contact printing; covalent and non-covalent binding; and chemo/enzymatic synthesis. [4]



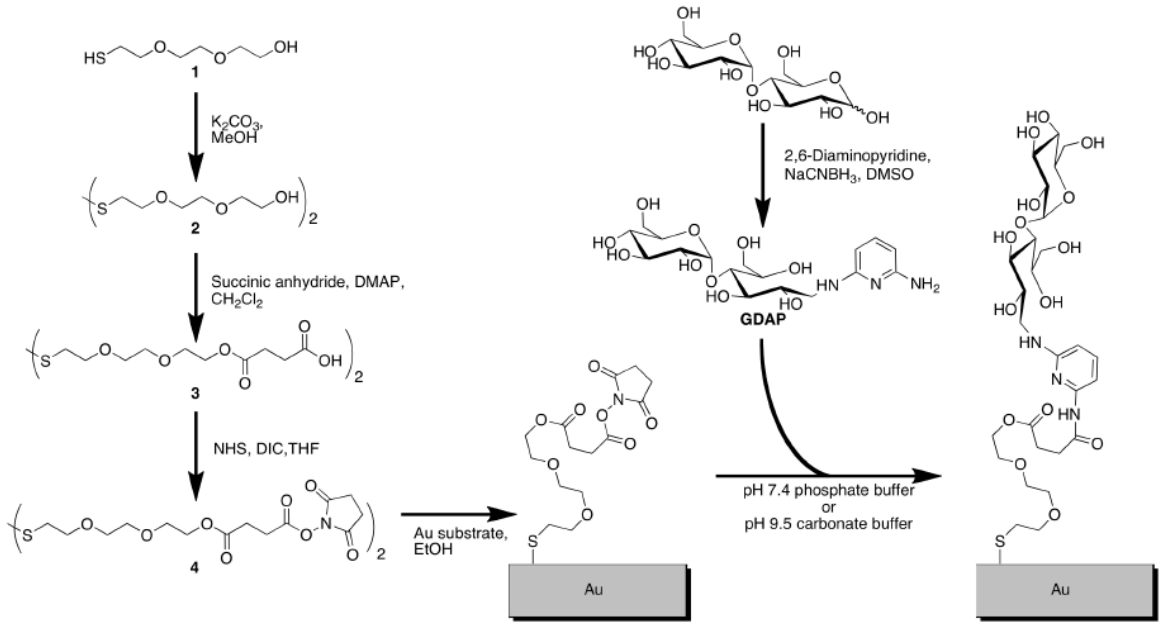
Scheme 4: Scheme of the covalent approach for the immobilization of oligosaccharides. [9]

[8] „Bacterial Glycoprofiling by Using Random Sequence Peptide Microarrays“ by Carlos Morales Betanzos, Maria J. Gonzalez-Moa, Kathryn W. Boltz, Brian D. Vander Werf, Stephen Albert Johnston, Sergei A. Svarovsky

[9] Zhou X C , Zhou J Z. Biosensors and Bioelectronics , 2006 , 21 : 1451 –1458



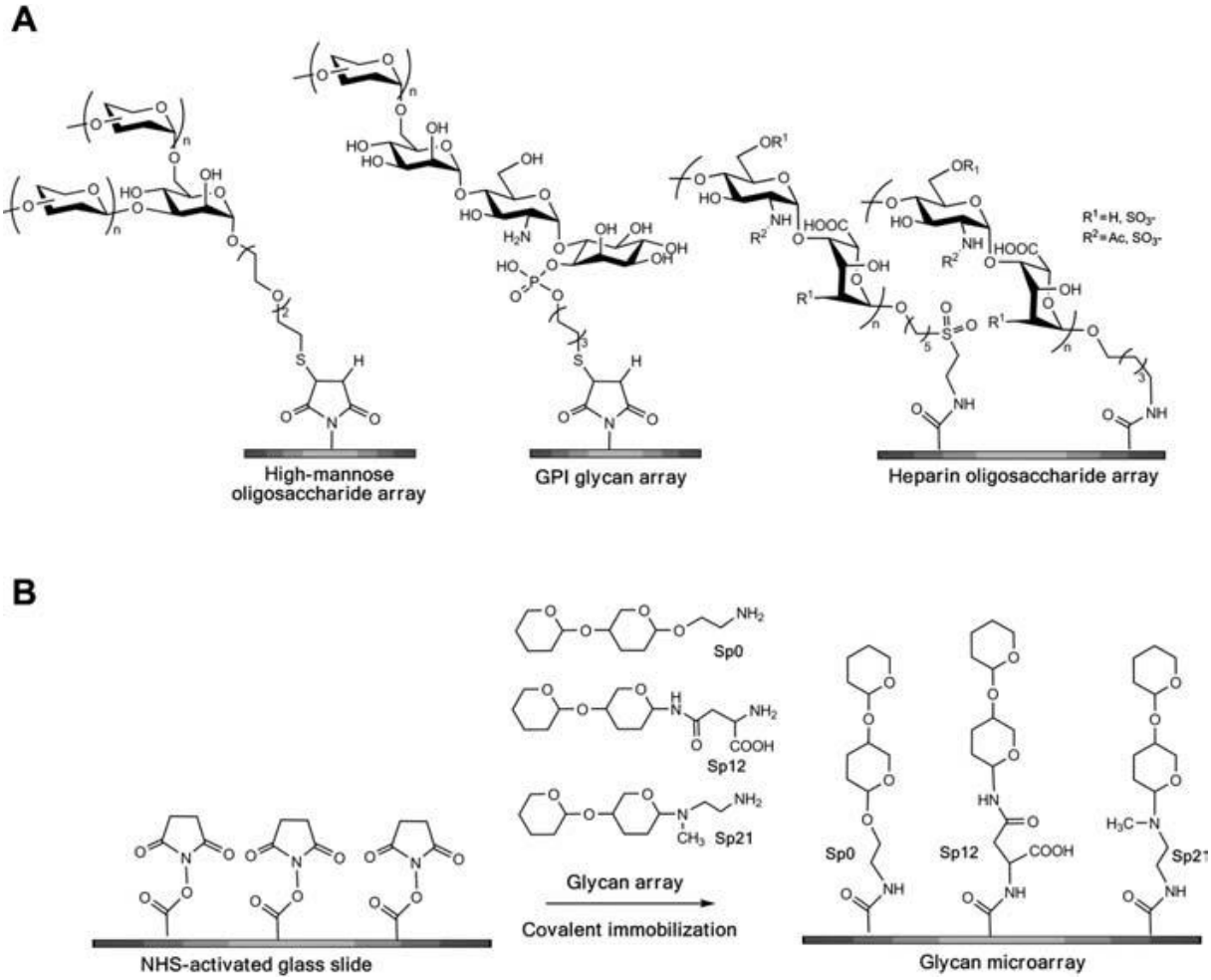
Scheme 5: A new noncovalent glycoarray assembly method for microarray created by simply mixing together an isocyanate-containing C14-hydrocarbon and an amine-containing carbohydrate. [10]



Scheme 6: Synthesis of amine-reactive surfaces for the immobilization of amino-functionalized carbohydrates (i.e. GDAP). [11]

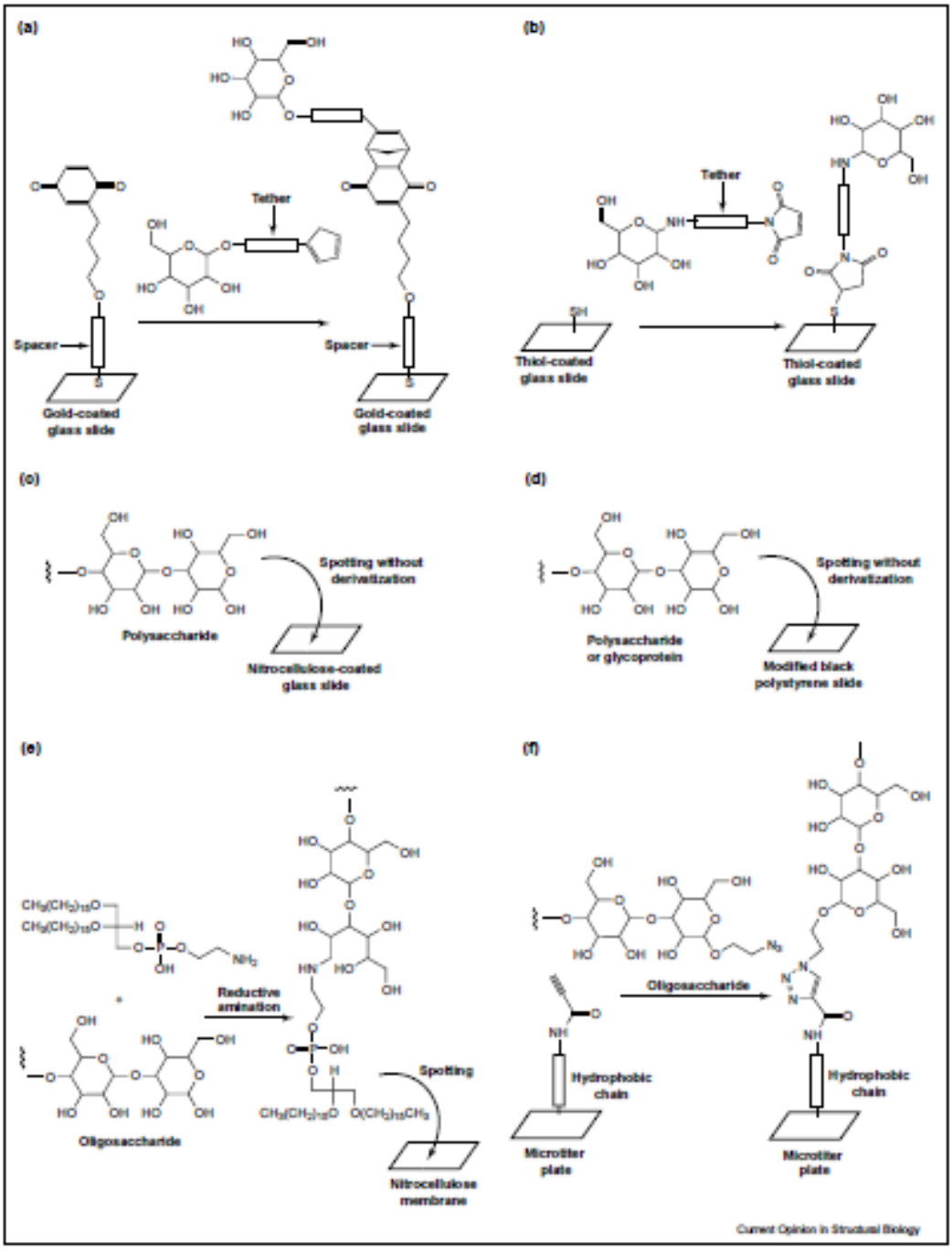
[10] Fazio F , Bryan MC , Lee H K, et al . Tetrahedron Letters , 2004 , 45 : 2689 –2692

[11] Bolles, K.M.; Cheng, F.; Burk-Rafel, J.; Dubey, M.; Ratner, D.M. Imaging Analysis of Carbohydrate-Modified Surfaces Using ToF-SIMS and SPRi. Materials. 2010, 3, 3948-3964.



Scheme 7: Examples of synthetic oligosaccharide microarrays. (A) Microarrays of synthetic high-mannose oligosaccharides, GPI glycan fragments, and heparin oligosaccharides developed by the Seeberger group. (B) Glycan arrays of CFG generated by covalent immobilization of glycans (with different amino-terminal spacers) printed onto NHS-activated glass slides. The designation of the spacers, Sp0, Sp12, and Sp21 are as described on the CFG website (http://www.functionalglycomics.org). [12]

[12] „Carbohydrate microarrays: key developments in glycobiology“ by Yan Liu, Angelina S. Palma and Ten Feizi



Scheme 8: Diagrammatic representation of the fabrication of carbohydrate microarrays. (a) Covalent immobilization on a gold surface by Diels–Alder reaction. (b) Covalent immobilization on a glass slide by hetero-Michael addition reaction. (c) Noncovalent polysaccharide adsorption without derivatization onto a nitrocellulose-coated glass slide. (d) Noncovalent polysaccharide and glycoprotein adsorption without derivatization onto a modified black polystyrene slide. (e) Noncovalent adsorption of NGLs onto a nitrocellulose membrane. (f) Noncovalent immobilization by hydrophobic interaction of a 14-carbon aliphatic chain with polystyrene wells. [13]

[13] „Carbohydrate microarrays — a new set of technologies at the frontiers of glycomics“ by Ten Feizi, Fabio Fazio, Wengang Chai and Chi-Huey Wong

A study of a three dimensional bacteria-catching array can be found [14]. This study used E. coli but the results could be generalized for cyanobacteria.

Because in our study specific detection of cyanobacteria isn't necessary, printing of the arrays onto cellulose is also not necessary. If we could just get the necessary array to attach to cellulose it would be more than enough. That could be done in a solution.

In the literature read, the carbohydrates were ususally attached by breaking of an –OH bond. Cellulose already has many –OH groups so previous treatment of cellulose besides dissolving may not be neccessary.

There are many nuances to the glycan array technique[15] but due to the nature of this study it's not necessary to delve into the specifics.

There has also been work done about detecting bacterial toxins [16]. Cyanobacteria is dangerous precisely because of its toxins. Maybe this work can be applied to binding cyanobacteria's toxins.

Some of the most relevant work is very specific [17]. Also there's lots of information about antibacterial substances (i.e. coatings used in shipping and medicine) but not much information about binding bacteria (except in the field of carbohydrate microarrays but that has an analytical leaning to it).

[14] „Fabricating three-dimensional carbohydrate hydrogel microarray for lectin-mediated bacterium capturing" by Xia Liu, ZhenLei, FuyaoLiu, DianjunLiu, ZhenxinWang

[15] „OPTIMIZATION AND IMAGING ANALYSIS OF CARBOHYDRATE MICROARRAYS" by Kathryn McGregor Bolles

[16] „Detection of bacterial toxins with monosaccharide arrays" by Miriam M. Ngundi, Chris R. Taitt, Scott A. McMurry, Daniel Kahne, Frances S. Ligler

[17] „Protein Structure and Folding - Bacteria Binding by DMBT1-SAG-gp-340 Is Confined to the VEVL XXXXW Motif in Its Scavenger Cysteine-rich Domains"