Arsenite regulates prolongation of glycan residues of membrane glycoprotein: a pivotal study via wax physisorption kinetics and FTIR imaging

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Background: Arsenic exposure results in several human cancers, including those of the skin, lung, and bladder. As skin cancers are the most common form, epidermal keratinocytes (KC) are the main target of arsenic exposure. The mechanisms by which arsenic induces carcinogenesis remains unclear, but aberrant cell proliferation and dysregulated energy homeostasis play a significant role. Protein glycosylation is involved in many key physiological processes, including cell proliferation and differentiation.

Methods: To evaluate whether arsenite exposure affected protein glycosylation, the alteration of chain length of glycan residues in arsenite treated skin cells was estimated.

Results: Herein we demonstrated that the protein glycosylation was adenosine triphosphate (ATP)-dependent and regulated by arsenite exposure by using Fourier transform infrared (FTIR) reflectance spectroscopy, synchrotron-radiation-based FTIR (SR-FTIR) microspectroscopy, and wax physisorption kinetics coupled with focal-plane-array-based FTIR (WPK-FPA-FTIR) imaging. We were able to estimate the relative length of surface protein-linked glycan residues on arsenite-treated skin cells, including primary KC and two skin cancer cell lines, HSC-1 and HaCaT cells. Differential physisorption of wax adsorbents adhered to long-chain (elongated type) and short-chain (regular type) glycan residues of glycoprotein of skin cell samples treated with various concentration of arsenite was measured. The physisorption ratio of beeswax remain/n-pentacosane remain for KC cells was increased during arsenite exposure. Interestingly, this increase was reversed after oligomycin (an ATP synthase inhibitor) pretreatment, suggesting the chain length of protein-linked glycan residues is likely ATP-dependent.

Conclusion: This is the first study to demonstrate the elongation and termination of surface protein-linked glycan residues using WPK-FPA-FTIR imaging in eukaryotes. The result may provide a scientific basis to target surface protein-linked glycan residues in the process of arsenic carcinogenesis.