Detecting and Degrading Formaldehyde Using Synthetic Biology and Engineering Techniques

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Formaldehyde, an aldehyde, is a carcinogenic pollutant found in air and water due to its wide usage by several industries in addition to several other aldehydes. The NIH states: most aldehydes such as formaldehyde, are one of the most common causes of lung, oral, and gastrointestinal cancer. However, in many countries including developing ones, there are no efficient and cost-effective methods of removing formaldehyde from wastewater. Aspergillus oryzae, a fungi widely used in the biotechnology industry, holds a gene named alcA (encodes formaldehyde dehydrogenase) that degrades formaldehyde into formate, NADH, and H^+. This project creates a recombinant Escherichia coli K-12 strain that contains the alcA gene to rapidly degrade large amounts (80% of formaldehyde solution of 10 ppm) of formaldehyde. The gene was inserted into pBBR1MCS-2, an expression vector. The plasmid also provided the bacteria with kanamycin resistance. The plasmid containing the gene of interest was isolated using specific primers and inserted via heat shock. The presence of the gene in the bacteria was confirmed using M13 primers and plasmid presence was confirmed due to growth on kanamycin plates. In addition, a low-cost detector was created using a polydimethylsiloxane (PDMS) microfluidic device and a photo-colorimetric sensor (based on an Arduino microcontroller board) for in-line detection. Polluted water containing formaldehyde is reacted with acetylacetone solution to produce a yellow hue (by Hantzsch reaction) which is detected and then given a yellow intensity value ranging 15 and above. The device will run autonomously, testing polluted water hourly using a motorized pump. These findings can be extrapolated to larger pollutant aldehydes with similar effects as formaldehyde.