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Detection of Glyphosate Using Disposable Sensors for Fast, Inexpensive and Reliable Measurements by Electrochemical Technique

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Abstract : Pesticides have been intensively used in agriculture to control weeds, insects, fungi, and pest. One of the most commonly used pesticides is glyphosate. Glyphosate has the ability to attach to the soil colloids and degraded by the soil microorganisms. As glyphosate led to the appearance of resistant species, the pesticide was used more intensively. As a consequence of the heavy use of glyphosate, residues of this compound are increasingly observed in food and water. Recent studies reported a direct link between glyphosate and chronic effects such as teratogenic, tumorigenic and hepatorenal effects although the exposure was below the lowest regulatory limit. Today, pesticides are detected in water by complicated and costly manual procedures conducted by highly skilled personnel. It can take up to several days to get an answer regarding the pesticide content in water. An alternative to this demanding procedure is offered by electrochemical measuring techniques. Electrochemistry is an emerging technology that has the potential of identifying and quantifying several compounds in few minutes. It is currently not possible to detect glyphosate directly in water samples, and intensive research is underway to enable direct selective and quantitative detection of glyphosate in water. This study focuses on developing and modifying a sensor chip that has the ability to selectively measure glyphosate and minimize the signal interference from other compounds. The sensor is a silicon-based chip that is fabricated in a cleanroom facility with dimensions of 10×20 mm. The chip is comprised of a three-electrode configuration. The deposited electrodes consist of a 20 nm layer chromium and 200 nm gold. The working electrode is 4 mm in diameter. The working electrodes are modified by creating molecularly imprinted polymers (MIP) using electrodeposition technique that allows the chip to selectively measure glyphosate at low concentrations. The modification included using gold nanoparticles with a diameter of 10 nm functionalized with 4-aminothiophenol. This configuration allows the nanoparticles to bind to the working electrode surface and create the template for the glyphosate. The chip was modified using electrodeposition technique. An initial potential for the identification of glyphosate was estimated to be around -0.2 V. The developed sensor was used on 6 different concentrations and it was able to detect glyphosate down to 0.5 mgL^{-1}. This value is below the accepted pesticide limit of 0.7 mgL^{-1} set by the US regulation. The current focus is to optimize the functionalizing procedure in order to achieve glyphosate detection at the EU regulatory limit of 0.1 μgL^{-1}. To the best of our knowledge, this is the first attempt to modify miniaturized sensor electrodes with functionalized nanoparticles for glyphosate detection.

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