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Abstract

Molecularly Imprinted Nanogels for Spike S1 Protein Recognition †

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Abstract: In the context of the global COVID-19 pandemic caused by the highly transmissible SARS-CoV-2 virus, molecularly imprinted polymers (MIPs) have emerged as a cutting-edge solution for the specific recognition of the Spike S1 protein, a crucial element in the virus's cellular entry. This pandemic determined challenges in rapid virus detection, mutation monitoring, and vaccine distribution. MIPs, with their specific binding sites, offer a unique approach to selectively capture and detect the Spike S1 protein, providing a basic start for rapid diagnostics or targeted therapeutics. This work presents the potential of MIPs in solving the complex SARS-CoV-2 problem, highlighting the promising combination of nanotechnology, molecular imprinting, and virology to combat the ongoing global crisis and prepare for future viral threats.

Keywords: nanogels; molecularly imprinted polymers; inverse-mini emulsion polymerization

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Introduction: The COVID-19 pandemic has highlighted the critical need for rapid and accurate detection of the SARS-CoV-2 virus. One approach to achieve this is through the development of synthetic antibodies that can selectively bind to the Spike S1 protein, a key component of the virus responsible for transmitting the viral entity into host cells [1]. Nanogels are described as particles that are composed of a 3D network of crosslinked polymer chains, typically with a size range between 10 and 200 nm. They can be designed to have a variety of properties, such as high water content, biocompatibility, and stimuli-responsiveness. Nanogels have a wide range of potential applications in fields such as drug delivery, tissue engineering, and biosensing, due to their ability to encapsulate and release therapeutic agents in a controlled manner, as well as their ability to mimic natural biological structures [2]. Molecularly imprinted polymers (MIPs) are a promising class of synthetic materials that can be designed with high specificity and sensitivity toward their target molecule [3]. Therefore, the present study describes the synthesis of MIP nanogels (MIP-SNAs) by an inverse mini-emulsion polymerization process which involves imprinting the template molecule into a hydrogel matrix. The resulting MIP-SNAs can be used as a sensitive and selective tool for the detection of the Spike S1 protein, offering potential advantages over traditional antibody-based assays.

Materials and methods: The molecularly imprinted synthetic nanogels (MIP-SNA) were obtained through polymerization in inverse mini-emulsion in the presence of the

SARS-CoV-2 Spike S1 protein RBD (PSS1) as a template and using two polyethylene glycol diacrylate monomers.

Results: The physicochemical characterization of PEGDA macromonomer and MIP-SNA was carried out using different techniques such as FTIR, TGA/DTG, DLS, and SEM. The similarity between the FTIR spectra of NIP-SNA and MIP-SNA confirmed that the chemical structure of MIP-SNA, which is based on non-covalent bonds, was not modified during the imprinting process. TGA/DTG analyses confirmed the presence of both macromonomers and protein/emulsifiers in the structure of MIP-SNA. Particle size was analyzed using DLS, and SEM images highlighted the individual spherical structures of the synthesized particles.

Conclusions: In this work, studies were conducted to obtain and characterize the physicochemical and morphological properties of MIP-SNAs based on polyethylene glycol diacrylate in the presence of Spike S1 protein used as a template, through polymerization in inverse mini-emulsion. The characterization of the samples confirmed the presence of the compounds of interest and indicated the desired size for the potential application. The future is indeed promising and in the coming years, there will be unprecedented progress in the control and manufacture of such systems and the translational application of these intelligent structures on a large scale in pharmacy, medicine, tissue engineering, sensors and diagnostics, micro and nano-diagnostics, and separation processes.

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