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Peptide Microarray Chips: Recent Advances in Preparation

Techniques and Applications

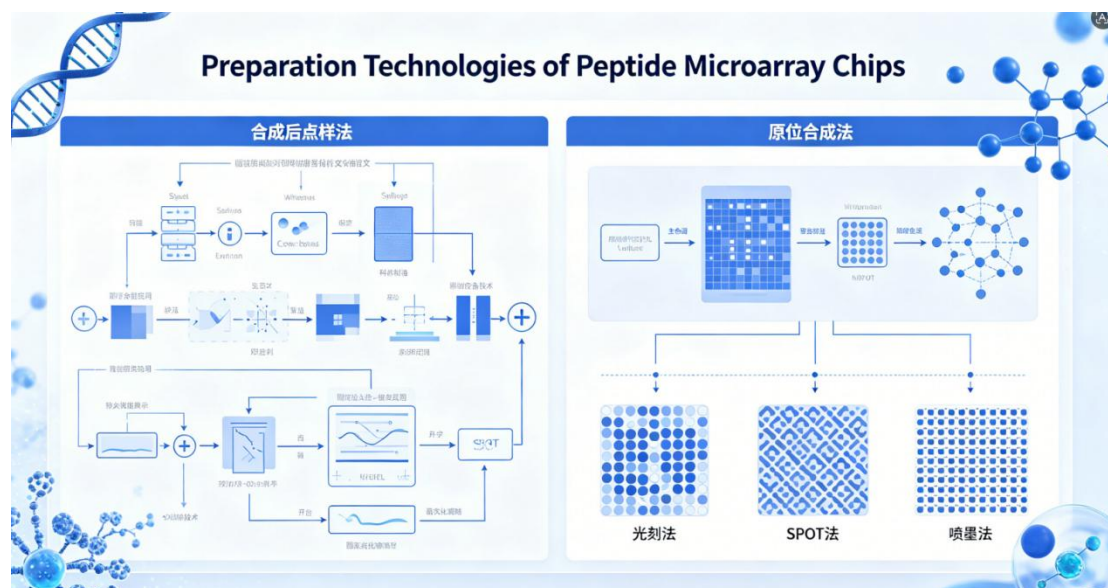
As high-throughput bioanalytical tools, peptide microarray chips have become a core technology in the fields of life sciences, clinical diagnostics, and drug discovery, thanks to their advantages of high efficiency, precision, and parallel processing. Recent studies have systematically reviewed the evolution of their fabrication technologies and diverse applications, providing valuable insights for technological optimization, application expansion, and industrial translation, thereby propelling biomedical research into a new era of high efficiency and precision.

I. Research Background

With the rapid development of proteomics and precision medicine, traditional low-throughput analytical techniques are struggling to meet the demands of large-scale biological sample screening. Peptide microarray chips enable the high-density immobilization of peptide probes on solid-phase substrates, facilitating high-throughput parallel detection, and hold great potential in fields such as antigen-antibody interactions, enzyme activity analysis, and biomarker screening. However, variations in

preparation techniques directly impact chip throughput, purity, and stability, limiting standardized applications. Therefore, a systematic summary of preparation techniques and application progress is crucial for advancing technological maturity and clinical translation.

II. Research Objectives and Significance



This study aims to comprehensively review the principles, advantages, disadvantages, and applicable scenarios of mainstream peptide microarray chip fabrication techniques, such as post-synthesis spotting and in situ synthesis, while comparing patterning strategies including photolithography, SPOT, and inkjet printing. It also summarizes their application value in fields such as epitope mapping, enzyme activity research, disease diagnosis, and drug screening. The findings provide a basis for researchers to select appropriate technologies and optimize process parameters, driving the development of peptide microarray chips toward high-throughput, high-stability, low-cost, and standardized

solutions. This will accelerate their transition from the laboratory to clinical and industrial applications, thereby advancing precision medicine and innovative drug development.

III. Research Content

The research team provided a detailed analysis of the two core preparation technologies for peptide microarray chips: the post-synthesis spotting method involves synthesizing high-purity peptides before immobilization; while it is simple to operate and yields high probe purity, it has low throughput and is time-consuming; The in situ synthesis method synthesizes peptides directly on the substrate, offering high throughput and density. It is divided into three categories: photolithography, SPOT, and inkjet—photolithography offers high precision and is suitable for automation, the SPOT method is flexible and low-cost, and the inkjet method is an emerging technology with great potential. Additionally, this review highlights their wide-ranging applications: in the life sciences for epitope mapping, enzyme activity analysis, and molecular interaction studies; in clinical medicine to aid in the early diagnosis of infectious diseases, cancer, and neurological disorders; and in drug discovery to enable high-throughput screening of bioactive peptides and target validation.

IV. Conclusions and Outlook

Research indicates that different peptide microarray chip fabrication

technologies have their respective advantages and disadvantages. In situ synthesis is well-suited for high-throughput applications, while post-synthesis spotting is ideal for low-throughput, high-purity scenarios. These technologies hold significant value in scientific research, clinical practice, and drug development, but they still face challenges such as probe stability, cost, and data analysis efficiency. Future efforts will focus on optimizing fabrication processes, enhancing chip stability, and reducing costs. By integrating artificial intelligence and microfluidic technologies to improve data analysis and integrated applications, we aim to advance the standardization and industrialization of peptide microarray chips, thereby providing efficient tools for precision medicine and innovative drug development.