# **ABSTRACT**

The present study focuses on the innovative potential of microgels and nanomaterials in targeted cancer therapies, immunoglobulin identification (especially IgG) and diagnostic procedures. It also emphasizes the revolutionary effect of combining fiber optics with miniature Lab-on-a-Chip (LoC) systems, which improves and speeds up diagnostics in science and medicine. This integration contributes to improvements in point-of-care testing, personalized healthcare, and environmental analysis by reducing sample sizes, expediting analysis, and increasing precision. These developments in technology highlight how important they have been in improving medical diagnosis methods and therapeutic strategies. The specificity and effectiveness of cancer treatments are improved using microgels, which are versatile carriers for drug delivery and biomarker detection due to their tuneable size and surface chemistry. Through the conjugation of microgels with antibodies, we can target cancer cells with precision, improving treatment safety and efficacy while also facilitating early, highly sensitive cancer detection through accurate biomarker recognition. This feature of microgels offers a path to more individualized and minimally invasive treatment modalities, which holds great promise for revolutionizing cancer diagnostics and therapy.

In parallel, we explore the field of liquid biopsy methods enhanced by nanomaterials. Making use of the inherent benefits of microfluidics and nanotechnology, this method represents a breakthrough in IgG detection, which is crucial for the diagnosis and tracking of numerous illnesses. Liquid biopsy's novel nanomaterial combination overcomes the drawbacks of conventional IgG detection techniques to provide biomolecular recognition that is quicker, more precise, and more affordable. This development holds great promise for widespread clinical applications, expedited disease intervention, and effective point-of-care diagnostics.

This study's experimental component involved a laborious process of conjugating antibodies onto microgel surfaces. The microgels were first activated with EDC using Atto 448 dye, and then human IgG antibodies were incubated on them. To fine-tune microgel settings, our research involved preparing slides under various conditions. This procedure involved producing control slides that were both unwashed (dry) and washed and that were treated with 10 µg/ml and 40 µg/ml of antibodies that were applied using EDC under both dry and wet conditions. Identifying the ideal setup for microgel tuning was the goal. According to ImageJ analysis, the microgel concentration peaked at 0.25 µg/ml and the antibody dose peaked at 40 µg/ml, respectively, and under dry conditions. The process's completion required careful slide preparations, including the use of several solutions to assess conjugation efficiency. This work greatly advanced the development of medical diagnostic and treatment approaches. As a result, this study concludes that the density of microgels can be directly influenced by changing their quantity, with more microgels increasing it and fewer reducing it. In the future, we hope to greatly improve our research methodology by incorporating a multiplex assay technique. The assays will be conducted using ELISA techniques (single Beads ELISA). This innovative approach will use a variety of antibodies and biomarkers, such as CA 125 and CEA, applied to microgels that have been specially adjusted. This innovation represents a major advancement in medical diagnostics, not only in speeding up the detection of cancer but also in the vast potential it holds for a variety of point-of-care applications.

**Keywords**: Microgels, Lab-on-a-Chip (LoC), Cancer Therapy, Diagnostics, Nanomaterials, Liquid Biopsy, IgG Detection, Antibody Conjugation, Single Beads ELISA, Targeted Drug Delivery, Biomarker Recognition, Nanotechnology, Microfluidics, Point-of-Care Testing.