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Ingestible pill for the detection of inflammatory bowel diseases

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Extended Abstract

Gastrointestinal inflammatory and immune-based diseases, such as ulcerative colitis and Crohn's disease, are becoming more common and appearing at younger ages. These diseases are believed to be caused by an abnormal activation of the immune system in a genetically susceptible host against elements of the enteric microbiota, which triggers the inflammatory mechanisms that lead to intestinal injury [1]. Although their etiology is not fully understood [2], it is accepted that a complex interaction between the host's immune system, genetics, microbiota, and environmental factors is the most likely causal agent, in which the imbalance between proinflammatory and anti-inflammatory cytokines and the alteration of the composition and function of the intestinal microbiota (dysbiosis) play a fundamental role[3]. In summary, inflammatory bowel diseases (IBD) are caused by an abnormal activation of the immune system in a genetically susceptible host against elements of the enteric microbiota, which triggers the inflammatory mechanisms that lead to intestinal injury. Therefore, effective in-situ monitoring of relevant biomarkers in the gastrointestinal tract (GI) plays a decisive role in the early diagnosis and treatment of these disorders [4]. Currently, the diagnosis of IBD is performed either through stool analysis or endoscopic techniques, which, in addition to being invasive technologies that involve tissue biopsy, are complex to access certain regions of the digestive tract and do not allow for patient monitoring over prolonged periods of time. The ONBODY project aims to develop a miniaturized ingestible device that allows for early, reliable, and real-time diagnosis of these diseases through the detection of cytokines that regulate the immune and inflammatory response in the GI.

The present work reports the development of a biocompatible capsule with immunoelectrochemical-based sensors for detecting proinflammatory and anti-inflammatory related cytokines. The electronic sensing module is based on a high precision, electrochemical front end which allows potentiometric, amperometric and impedimetric measurements. A low-power MCU is used to control the system and the measuring module in a time predefined basis or under request, and a NFC chip allows waking up the system from an external device and sending back the measured information, using a coil antenna of 1cm diameter wrapped around the electronics. Each of these sensing, processing and communication modules are integrated into a 9.6mm diameter round rigiflex printed circuit boards (PCB) with the flex interconnection between PCBs allowing the stacking of the three boards with robust and reliable connections in a miniaturized form factor. All the electronic components are power supplied by two silver-oxide batteries of 9.5mm diameter and 5.4 mm height with 82 mA/h capacity. A combination of engineered materials is designed to shelter the electronic components in a non-degradable capsule, make the sensing compartment permeable to liquid samples, and prevent the components' degradation and exposure along the GI tract's acid section, which ensures a specific actuation of the pill from the intestine.

By combining features like biosensing elements with wireless electronics in conjunction with bioengineered materials, this system provides real-time assessment of IBD.

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