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Carbon dots induce pathological damage to the intestine via causing intestinal flora dysbiosis and intestinal inflammation

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Abstract

Background Carbon dots (CDs), as excellent antibacterial nanomaterials, have gained great attention in treating infection-induced diseases such as periodontitis and stomatitis. Given the eventual exposure of CDs to the intestine, elucidating the effect of CDs on intestinal health is required for the safety evaluation of CDs.

Results Herein, CDs extracted from ε-poly-L-lysine (PL) were chosen to explore the modulation effect of CDs on probiotic behavior in vitro and intestinal remodeling in vivo. Results verify that PL-CDs negatively regulate *Lactobacillus rhamnosus* (*L. rhamnosus*) growth via increasing reactive oxygen species (ROS) production and reducing the antioxidant activity, which subsequently destroys membrane permeability and integrity. PL-CDs are also inclined to inhibit cell viability and accelerate cell apoptosis. In vivo, the gavage of PL-CDs is verified to induce inflammatory infiltration and barrier damage in mice. Moreover, PL-CDs are found to increase the Firmicutes to Bacteroidota (F/B) ratio and the relative abundance of *Lachnospiraceae* while decreasing that of *Muribaculaceae*.

Conclusion Overall, these evidences indicate that PL-CDs may inevitably result in intestinal flora dysbiosis via inhibiting probiotic growth and simultaneously activating intestinal inflammation, thus causing pathological damage to the intestine, which provides an effective and insightful reference for the potential risk of CDs from the perspective of intestinal remodeling.

Keywords Carbon dots, Probiotics, Reactive oxygen species, Intestinal flora, Inflammation

Introduction

Carbon dots (CDs), as newly emerged carbon-based nanomaterials, have been extensively used in bioimaging, drug delivery, and antibacterial applications owing to their excellent optical properties, high stability, and small particle size [1–4]. Especially in curing the infected tissues, lysine-based CDs were confirmed to perform antibacterial effects against *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*) through the positive charge of amino acids and the excited reactive oxygen species (ROS), which effectively alleviates the bacterial infection and promotes skin wound healing [5]. Fucoidan-derived CDs were demonstrated to be capable of inhibiting the biofilm formation of *Enterococcus*

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