Edible Additives & Cellulosic Paper

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Assembly of biofibers into paper-based products fits well into green chemistry principles. Biobased additives such as cationic starch and carboxymethyl cellulose are widely used in the paper industry. Edible additives, which often can be regarded as "safer" than regular biobased additives, may also play a role in tailorable design of paper-based products.

Keywords: Paper-based products; Edible Additives; Green chemistry; Sustainability

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Edibles as a Driver for Process and Product Innovation

We human beings strive for a better tomorrow. To this end, new things can be very welcome. Edible materials, as a group of safe, nontoxic, and oftentimes renewable substances, have much potential in diversified applications, particularly in the case of new product design. Such materials are self-evidently usable in food processing and its aligned industries such as those related to packaging. Green products with specific functionalities are also designable by utilizing structural features of edible molecules. Exemplary products include triboelectric nanogenerators (Khandelwal *et al.* 2019), edible inks (Feng *et al.* 2019), and self-cleaning materials (Wang *et al.* 2016; Wang *et al.* 2018). It is possible that edible materials will act as a driver for developing new processes and products with tailorable features.

Edible Additives for Cellulosic Paper

Paper, as a versatile, biodegradable, and flexible biomaterial, is made from biomass. Converting chemically and/or mechanically liberated biofibers into paper-based products is an industrial paradigm of utilizing renewable lignocellulosic bioresources, which fits into the concept of sustainability. Highly efficient mass production of paper-based products for diversified applications necessitates the use of process/functional additives. Despite current reliance on synthetic polymers (*e.g.*, polyamidoamine epichlorohydrin), biobased additives have indeed found widespread use (Wu *et al.* 2018). Such "green" additives encompass a large group of chemicals: cationic starch, carboxymethyl cellulose, rosin dispersion, among others.

For the emergence of a more sustainable paper industry, what about the potential of edible additives? Indeed, native biomacromolecules including protein (*e.g.*, gelatin) and starch can be fully edible, and their recorded use as strength additives for paper is well known. Mineral particles such as bentonite, calcium carbonate, and silica are useful ingredients for pharmaceutical purposes and food use, and similar products are widely used as fillers, coating pigments, and microparticulate retention and drainage additives. Chitosan, as another type of edible material, can be effective as a surface sizing agent due

to the hydrophobic nature of chitosan films (Hubbe 2019). Since edible materials belong to a very diverse and abundant group of nontoxic substances, their use as additives for paper would have much potential, particularly in the case of edible coatings.

We think that edible additives, once efficiently used, may provide new possibilities of the paper industry. The scope of applications in terms of both edible molecules and paper-based products can also be broadened, facilitating the development of new products and processes. Our concept of using edible additives to deliver tailorable functionalities to paper-based products is shown in Fig. 1. Both internal and surface applications are promising strategies. It is noteworthy that, due to limitations such as those related to functional groups and molecular configurations, edible additives may not function as well as regular additives currently used in the industry. Combination of different edible additives for imparting different characteristics of cellulosic paper is a possible strategy to improve their performances. Surface engineering tends to be more versatile due to facile design of edible coatings in light of ever-developing area of food science and materials science.

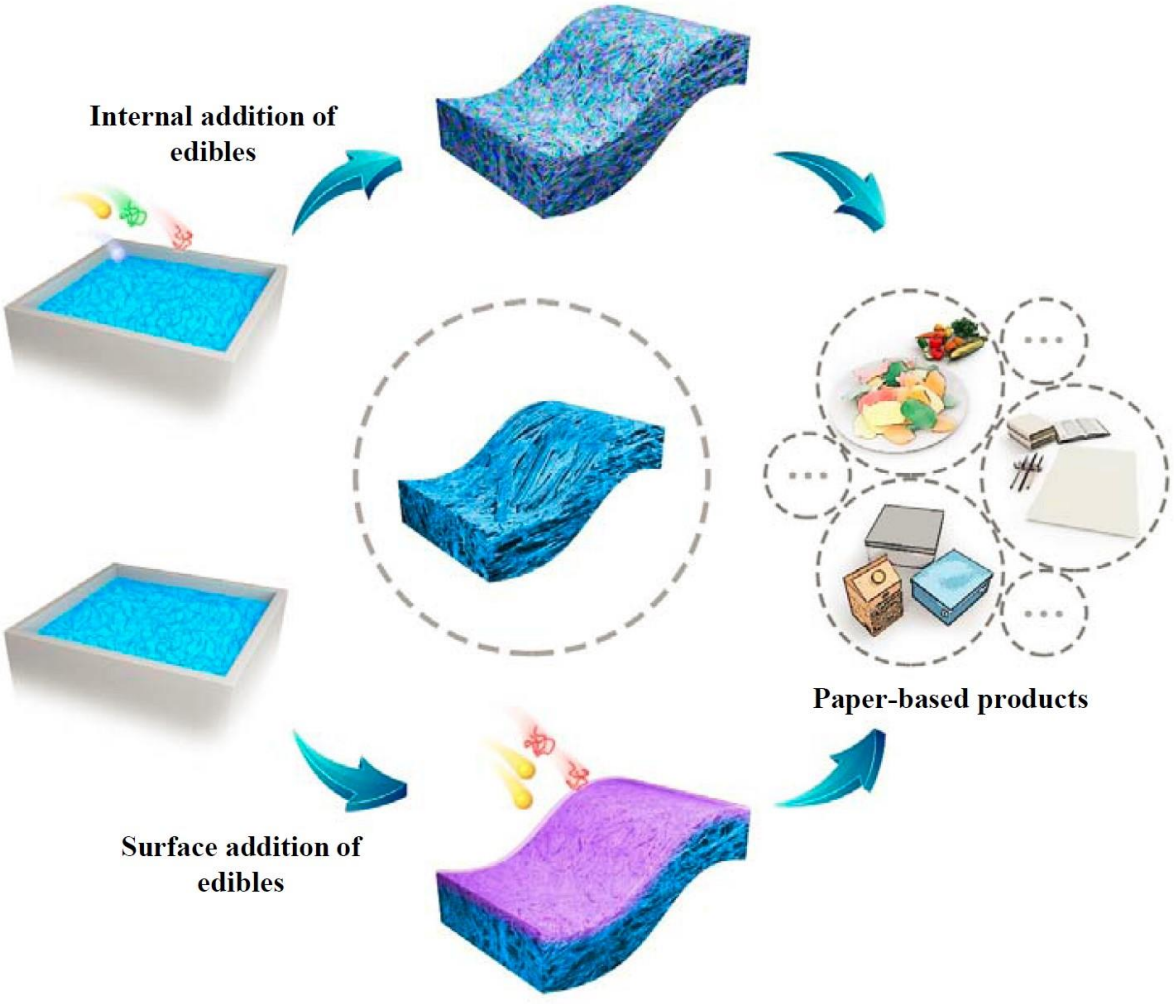

Fig. 1. Schematic illustration of the concept of internal and surface applications of edible additives for cellulosic paper

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References Cited

Feng, C., Zhang, M., and Bhandari, B. (2019). "Materials properties of printable edible inks and printing parameters optimization during 3D printing: A review," *Crit. Rev. Food Sci. Nutr.* 59(19), 3074-3081. DOI: 10.1080/10408398.2018.1481823

Hubbe, M. A. (2019). "Why, after all, are chitosan films hydrophobic?," *BioResources* 14(4), 7630-7631. DOI: 10.15376/biores.14.4.7630-7631

Khandelwal, G., Minocha, T., Yadav, S. K., Chandrasekhar, A., Maria Joseph Raj, N. P., Gupta, S. C., and Kim, S.-J. (2019). "All edible materials derived biocompatible and biodegradable triboelectric nanogenerator," *Nano Energy* 65, 104016. DOI: 10.1016/j.nanoen.2019.104016

Wang, P., Qian, X., and Shen, J. (2018). "Superhydrophobic coatings with edible biowaxes for reducing or eliminating liquid residues of foods and drinks in containers," *BioResources* 13(1), 1-2. DOI: 10.15376/biores.13.1.1-2.

Wang, W., Lockwood, K., Boyd, L. M., Davidson, M. D., Movafaghi, S., Vahabi, H., Khetani, S. R., and Kota, A. K. (2016). "Superhydrophobic coatings with edible materials," *ACS Appl. Mater. Interfaces* 8(29), 18664-18668. DOI: 10.1021/acsami.6b06958

Wu, D., Li, L., Wang, Y., Meng, Z., Qian, X., Wang, Y., and Shen, J. (2018). "Localized liquefaction coupled with rapid solidification for miniaturizing/nanotexturizing microfibrous bioassemblies into robust, liquid-resistant sheet," *ACS Sustainable Chem. Eng.* 6(11), 15697-15707. DOI: 10.1021/acssuschemeng.8b04215