doi:10.1017/S1431927622006377
Microsc. Microanal. 28 (Suppl 1), 2022
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Novel Gelatin-based Bioplastic Materials Designed to Replace Polystyrene and Polypropylene in Single-use Hard Plastics

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One of the best solutions to our growing plastic pollution crisis is the creation and usage of bioplastics, which is a type of biodegradable plastic derived from biological substances rather than from petroleum [1]. Gelatin serves as an excellent material to produce bioplastics because it is an abundant waste product of the meat industry. Therefore, gelatin has a much lower carbon footprint than plant starches (commonly used to make bioplastics) which use fertilizers, herbicides, and pesticides to produce [2]. Additionally, gelatin is also an all-natural, non-toxic, and renewable material derived from various animal origins such as pork, beef, poultry, fish, or a combination thereof. Gelatin also has a wide range of uses in different manufacturing processes for pharmaceutical, cosmetic, and tannery and is widely used in food production [3]. There has already been a great deal of progress in creating different bioplastics. One example is biodegradable films used for packaging which currently makes up 60% of the bioplastic production globally [4]. However, there is significantly less progress with disposable hard plastics. Therefore, the utilization of gelatin in the creation of hard bioplastics is critically important. In this work, we studied the gelatin-based hard bioplastics to understand impact of processing on the morphology using a scanning electron microscope (SEM) and Fourier transform infrared (FTIR) spectroscopy. For SEM imaging the gelatins sample was cut and sputter-coated with gold and imaged in a JEOL JSM-6510LV SEM. The FTIR spectra were collected in using attenuated total reflection (ATR) mode at the resolution 4 cm^{-1}. The prototypes of bioplastics were made using primarily gelatin [generic (Great Value), pure beef, and pure pork]. For each gelatin prototype, the bioplastic mixture was placed in an electric skillet on low heat (200-215°F) while constantly stirring. Once the mixture lightly boiled and thickened, a 1/8 measuring cup was used to pour the bioplastic material into molds. Once the material hardened enough to handle (2-3 hours), the samples were removed from the molds and flipped several times per day until completely cured (about one week).

Figure 1 shows SEM images of the cross-sectional structure of beef, pork, and generic gelatin-based prototypes. All samples have a rough and uneven surface. The beef gelatin has some cavities as indicated by the arrow **in Figure 1 (a)** which have different shapes elongated to somewhat circular. The elongated cavities have sizes 50 - 130 μm in length and circular have diameters 60 – 80 μm. The pork gelatin contains some cavities and pores (diameter 50 -70 μm) whereas the generic gelatin has few pores with diameter 30-60 μm and less cavities. The SEM results indicated that the pores are not uniformly distributed throughout the surface. To understand the porous nature of these gelatins, we measured the FTIR of dry and water treated samples (**Figure 2**). The broad peak in the range of 3000–3800 cm^{-1} is attributed to the O–H stretching of hydrogen bonded networks. The increase in intensity of the band is due to presence of more O-H bonded networks (eg. Water). There is 27% increase in intensity of generic gelatin when exposed to water for thirty seconds whereas the increase is ~50 % on both beef and pork gelatin. This observation suggests that less porous structure of generic gelatin compared to beef or pork gelatin supporting the observation from SEM as generic gelatin have less number of cavities [6].

https://doi.org/10.1017/S1431927622006377 Published online by Cambridge University Press

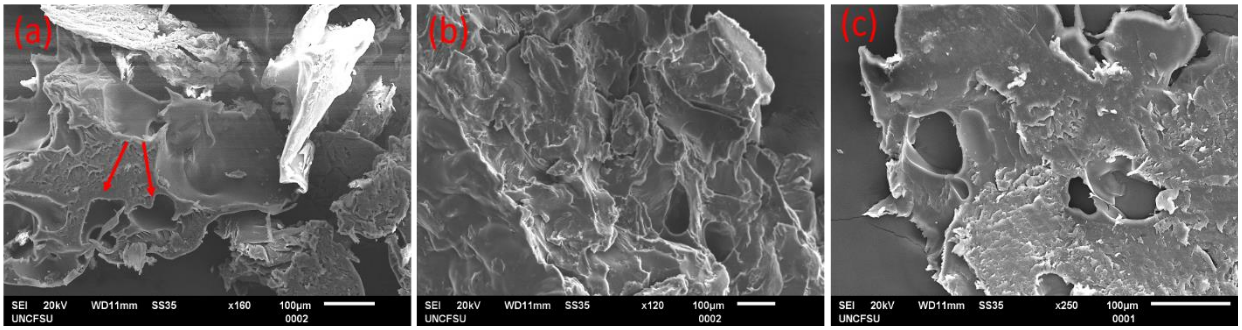

Figure 1. SEM images of (a) beef gelatin, (b) pork gelatin, and (c) generic gelatin

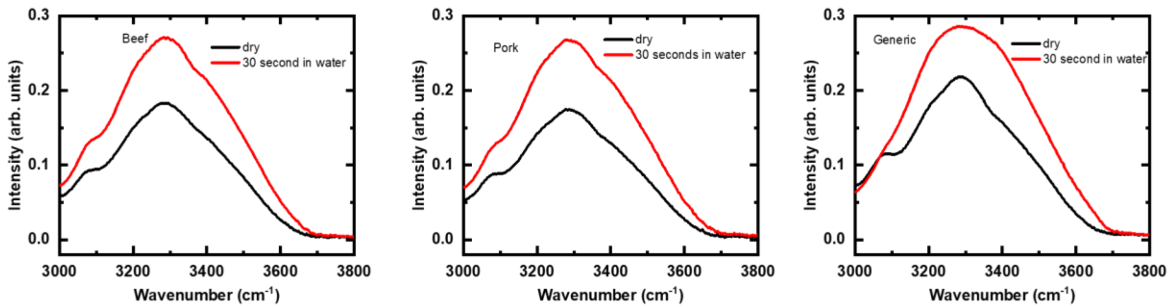

Figure 2: FTIR spectra of dry and water treated gelatin (a) Beef (b) Pork (c) Generic

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[6] This work was supported by NSF RIA (HRD 1900998) and EIR (ECCS-1900837).

https://doi.org/10.1017/S1431927622006377 Published online by Cambridge University Press