Electronic Supplementary Material (ESI) for New Journal of Chemistry.

New Journal of Chemistry

Supporting information

Preparation of eco-friendly composite food packaging films based on gelatin and matrine coconut acids ionic liquid

Hao Wang[a,b,#], Yixiang Du [a,b,#], Zhenyuan Wang[c], Wen Yu[a,b], Ling Zhang[d], Chengyu Wu[a,b], Mi Wang[a,b,*] and Jiaheng Zhang [a,b,*]

[a]School of Material Sciences and Engineering, Harbin Institute of Technology (Shenzhen), Shenzhen, 518055, China

[b]Research Centre of Printed Flexible Electronics, School of Materials Science and Engineering, Harbin Institute of Technology, Shenzhen, 518055, China.

[c]Shenzhen Shinesky Biological Technology Co., Ltd., Taoyuan Street, Nanshan District, Shenzhen, 518055, China

[d]School of Material Science, Harbin Institute of Technology (Shenzhen), Shenzhen, 518055, China

[#] These authors contributed equally to this work.

*Corresponding Authors: Jiaheng Zhang, Mi Wang.

Eco-friendly food packaging films were prepared by compositing gelation with a bioactive ionic liquid showing excellent antioxidant and antibacterial properties.

Structure analysis of [Mat][Coc]

As a reflection of electron density, ESP analysis is of great significance to non-covalent interaction systems. Fig.S1 shows the electrostatic potential of each model. Blue represents the area of electronegativity, and red represents the area of positive charge. The greater the electronegativity of the element, the stronger the ability of its atom to attract electrons in the compound, and the stronger the hydrogen bond formed. The positively charged regions of lauric acid, capric acid, and caprylic acid are attracted to the negatively charged regions of matrine, obtaining stable [Mat][C12], [Mat][C10], [Mat][C8] configurations. This is also consistent with the conclusion in text 3.1 that the position of the hydrogen bond between the two and the strength of the hydrogen bond are high.

The front-line orbit proves that the electron gains and losses between the components and the degree of difficulty in the synthesis process and its energy level of ILS were shown Fig.S2. The smaller the value of ΔE (LUMO-HOMO) , the more unstable the molecule and the easier the reaction. For matrine lauric acid, matrine lauric acid, matrine caprylic acid ionic liquids, the difference in ΔE (LUMO-HOMO) values is very small, so the degree of difficulty of the reaction should be the same.

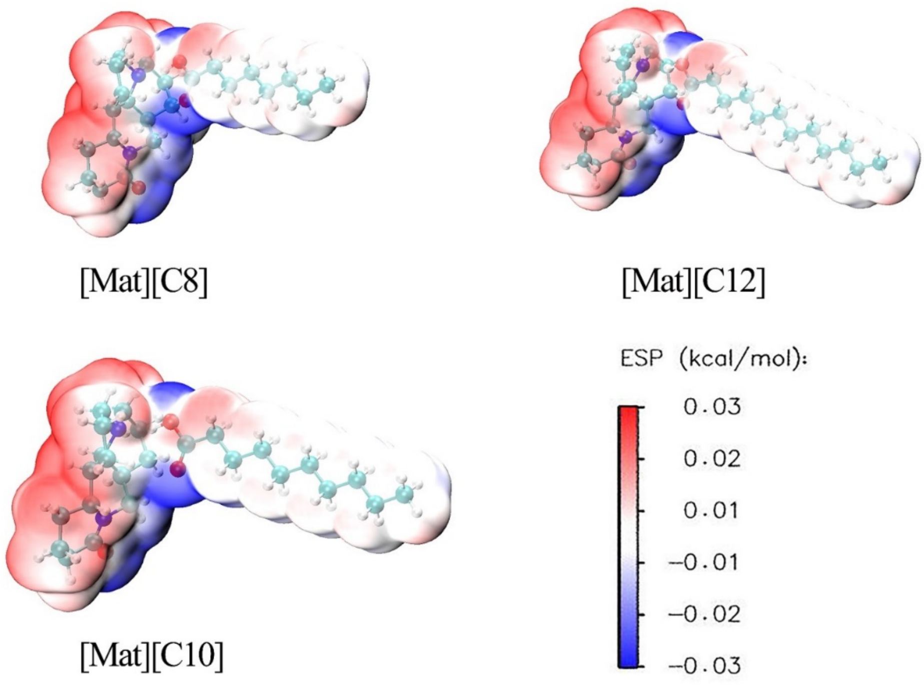

Fig.S1 Electrostatic potential diagram of matrine coconut acids

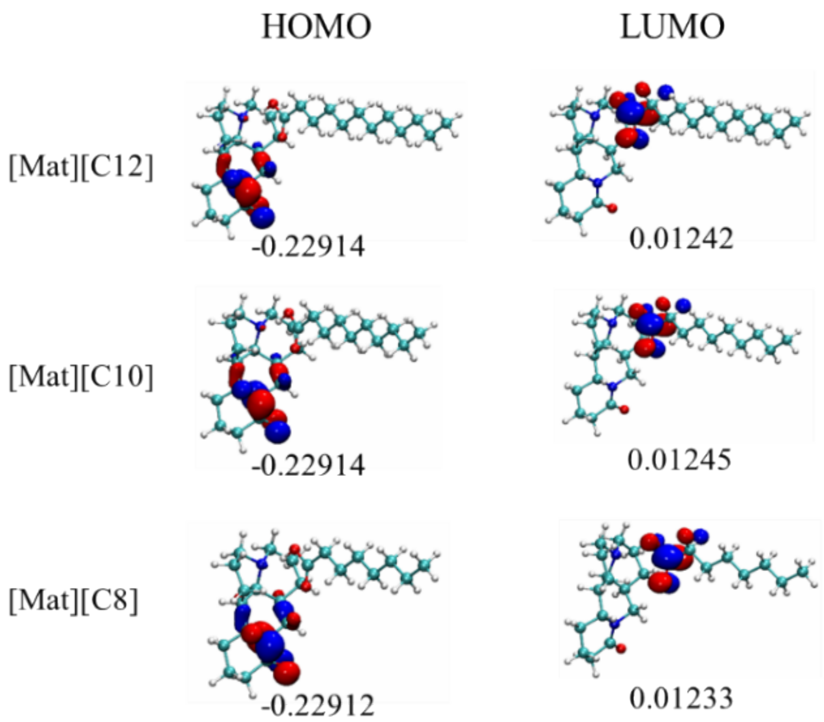

Fig.S2 Front Line Map of matrine coconut acids

Antioxidant Activity

In the ABTS free radical scavenging experiment,the standard curve of vitamin E (Trolox) on ABTS free radical scavenging was used to compare the antioxidant effect of the prepared [Mat][Coc] and the standard sample Trolox. By measuring the absorbance values of solutions with Trolox concentrations of 0.05 mM, 0.10 mM, 0.15 mM, 0.20 mM, and 0.30 Mm at 734 nm, a regression equation of Trolox's standard curve is Y=0.58326 -1.2017X obtained after subtracting the blank base from the obtained data (Fig.S3). Preparing mixed solutions of samples with different concentrations of [Mat][Coc] at 0.002 μl/ml, 0.01 μl/ml, 0.02 μl/ml and 0.04 μl/ml with ABTS working solution, reacting for 6 min under dark conditions, and measuring their absorbance (Table S1).

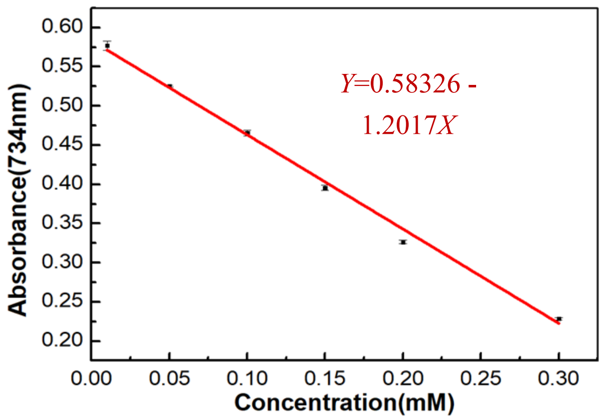

Fig.S3 Trolox standard curve

Table S1 Concentration ratio of matrine and coconut acid and Trolox equivalent

MC	Distilled water	ABTS working solution	Sample concentration	Trolox equivalent
10 μl	490 μl	4.5 ml	0.002 μl/ml	0.20 mM
50 μl	450 μl	4.5 ml	0.01 μl/ml	0.42 mM
100 μl	400 μl	4.5 ml	0.02 μl/ml	0.45 mM
200 μl	300 μl	4.5 ml	0.04 μl/ml	0.45 mM

Antibacterial activity

Table S2 compares the antimicrobial activities of [Mat][Coc] with different inclusion and absorbance.

Table S2 Concentration ratio of antibacterial test

Concentration	Bacteria	Culture medium	Sample
0%(control)	10 μl	990 μl	0 μl
5%	10 μl	940 μl	50 μl
10%	10 μl	890 μl	100 μl
20%	10 μl	790 μl	200 μl
30%	10 μl	690 μl	300 μl

Structural Analysis

Table S3 Thicknesses of the Gel/MC composite films (μm)

Content	5% MC	10% MC	20% MC	30% MC
Thickness	101.2±2.56	102.4±3.44	100.6±3.93	99.4±4.63

Optical Properties

The light transmittance and transparency of the sample can be characterized through the measurement of light transmittance and haze. With 550 nm representing the wavelength of visible light, the transmittance and haze of the prepared composite film were measured(Fig.S4). In Fig.S5 a), it can be seen that the sample also has a light transmittance of about 90% in the infrared range. But in Fig.S5 b) ,the light transmittance is continuously decreasing with the content of matrine coconut acid increases from 10% to 30% in the short wavelength range of 260 nm-400 nm. This shows that the addition of matrine coco acid improves the resistance of the composite film to ultraviolet rays.

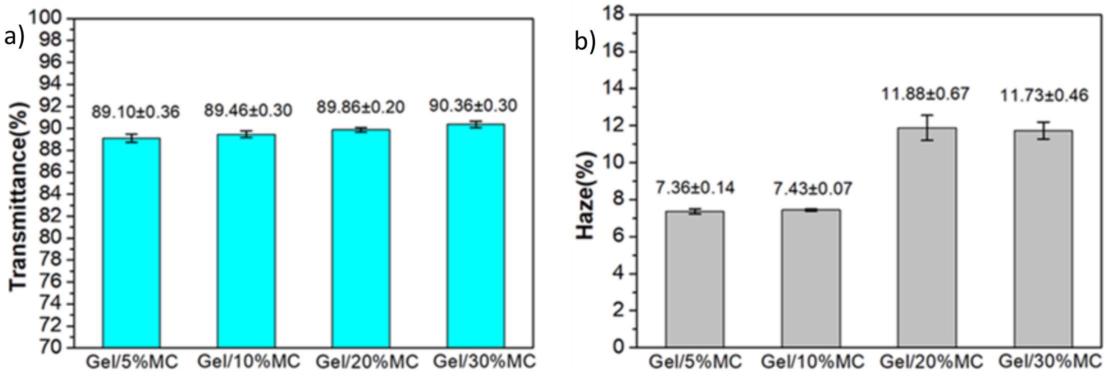

Fig. S4 a)Transmittance b)Haze of Gel/5%MC、 Gel/10%MC、Gel/20%MC、Gel/30%MC

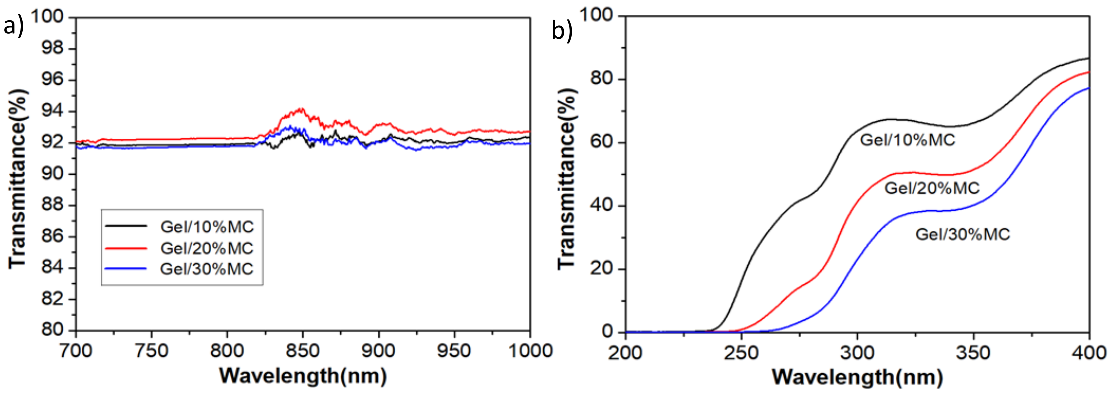

Fig. S5 Light transmittance of Gel/10%MC, Gel/20%MC, Gel/30%MC in the infrared a) 700-1000nm and ultraviolet b) 200-400nm

X-ray diffraction analysis was performed on the prepared film. The pure gelatin film is highly amorphous. As can be seen in Fig.S6, the XRD patterns of the Gel/MC composite films all exhibited broad peaks at around 2θ = 20°, which is similar to that of pure gelatin ([31] *Cent Eur J Chem*, 2009, **7**, 721-730). With different content of [Mat][Coc], the slight changes of the peak intensity and peak position are induced by the interactions between gelatin and [Mat][Coc].

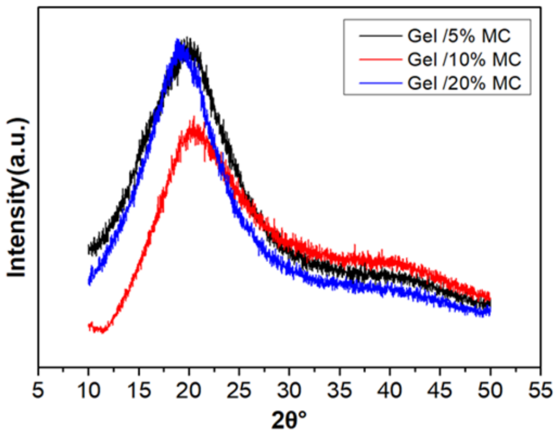

Fig.S6 XRD patterns of Gel/5%MC, Gel/10%MC and Gel/20%MC

Comparison with other bioactive gelatin-based films for food packaging

Table S4 Properties of some bioactive gelatin-based films

Polymer Matrix	Plasticizer	Functional Additives	*TS* (MPa)	*EAB* (%)	WVP($\times10^{-11}$ $gm^{-1}s^{-1}Pa^{-1}$)	Anti-bacterial	Anti-oxidant	Fresh keeping	Ref.
gelatin	30% glycerol	1/30 green tea extract	20.79	44.62	2094	--	√	√	[27]
gelatin-chitosan	--	--	16.1	9.34	7750	√	√	√	[28]
		quercetin-starch	17.11	5.1	7570				
gelatin	30% glycerol	50% Kaffir Lime	34.22	30.93	3.38	--	√	--	[32]
		50% bergamot	36.52	19.96	3.22				
		50% lemon	31.06	52.66	2.85				
gelatin-chitosan	30% glycerol	0.4% origanum vulgare L	38.82	35.31	22.13	√	--	--	[33]
gelatin	25% glycerol	1% carvacrol	~3.5	~130	~8.75	√	√	--	[34]
gelatin	25% glycerol	0.7% green tea extract	36.63	42.53	9.2	--	√	--	[35]
gelatin	--	50% L-cysteine 1% ε-polylysine	32.87	34.76	~22.5	√	√	--	[36]
gelatin	--	1.0%lecithin 0.5%thymol	2.96	94.72	7.19	√	--	--	[37]
gelatin	20% glycerol	rosmarinic acid 1%	36.39	65.58	~45	√	√	--	[38]
gelatin-chitosan	30% glycerol	1% melanin nanoparticles	41.8	9.7	~78	--	√	--	[39]
gelatin	5 % [Mat][Coc]		45.56	7.71	0.0719	√	√	√	This Work
	10 % [Mat][Coc]		11.39	19.27	0.1293				