Supporting Information

Ultra-Violet-light driven Green Oxygen Scavenging Composite made of PVA/NRL for Active Packaging: An Alternative to Metallic Oxygen Scavengers

Dakuri Ramakanth[1], Konala Akhila[2], Bittu Prudhvi Kumar[2], Kirtiraj K Gaikwad[2*], Pradip K Maji[1*]

[1]*Department of Polymer and Process Engineering, Indian Institute of Technology Roorkee, Saharanpur campus, Saharanpur -247001, Uttar Pradesh, India*

[2]*Department of Paper Technology, Indian Institute of Technology Roorkee, Roorkee -247667, Uttarakhand, India*

[*] **Corresponding authors**: Pradip K. Maji (Email: pradip@pe.iitr.ac.in)

Kirtiraj K. Gaikwad (Email: kirtiraj.gaikwad@pt.iitr.ac.in)

Total no. of pages- 7 (S1-S7)

Total no. of figures- 3

Total no of tables - 2

Supporting Information

Table S1. Detailed compositions used for the development of PVA-NRL water-based films as oxygen-scavenging systems

Sample code	Polyvinyl alcohol (g)	Natural rubber latex, (g)	Acetophenone (g)	Manganese chloride (g)
PNP 1:1	10	9.7	0.297	0.003
PNP 1:2	10	19.4	0.594	0.006
PNP 2:1	20	9.7	0.297	0.003

FTIR

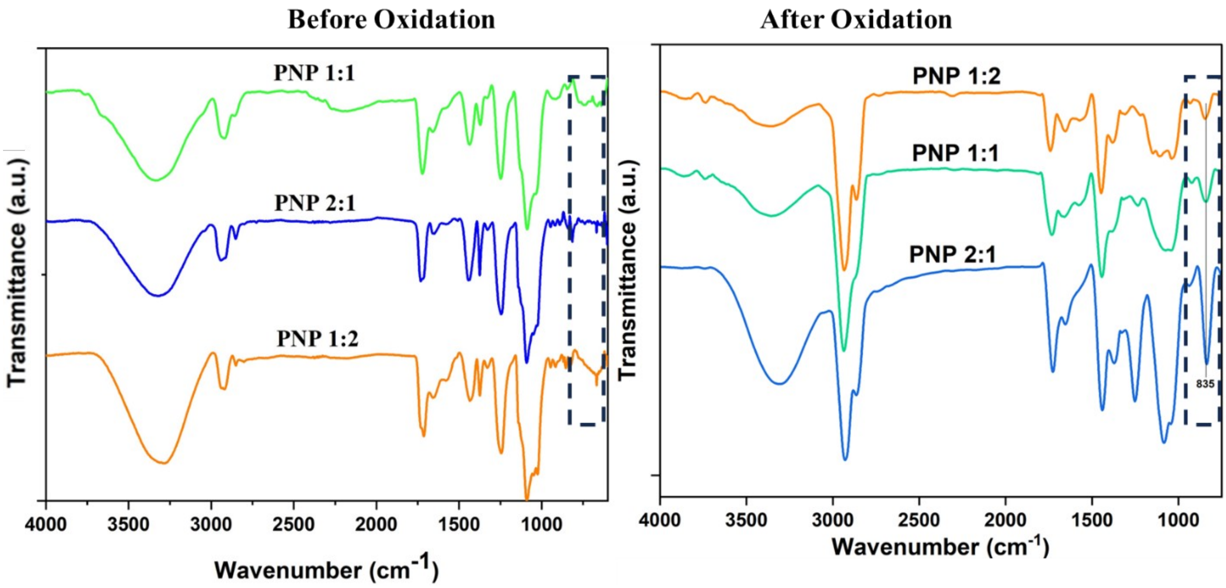

Fig. S1. Fourier transform infrared spectroscopy image of Polyvinyl alcohol-natural rubber latex-based films before and after oxygen scavenging reaction

Supporting Information

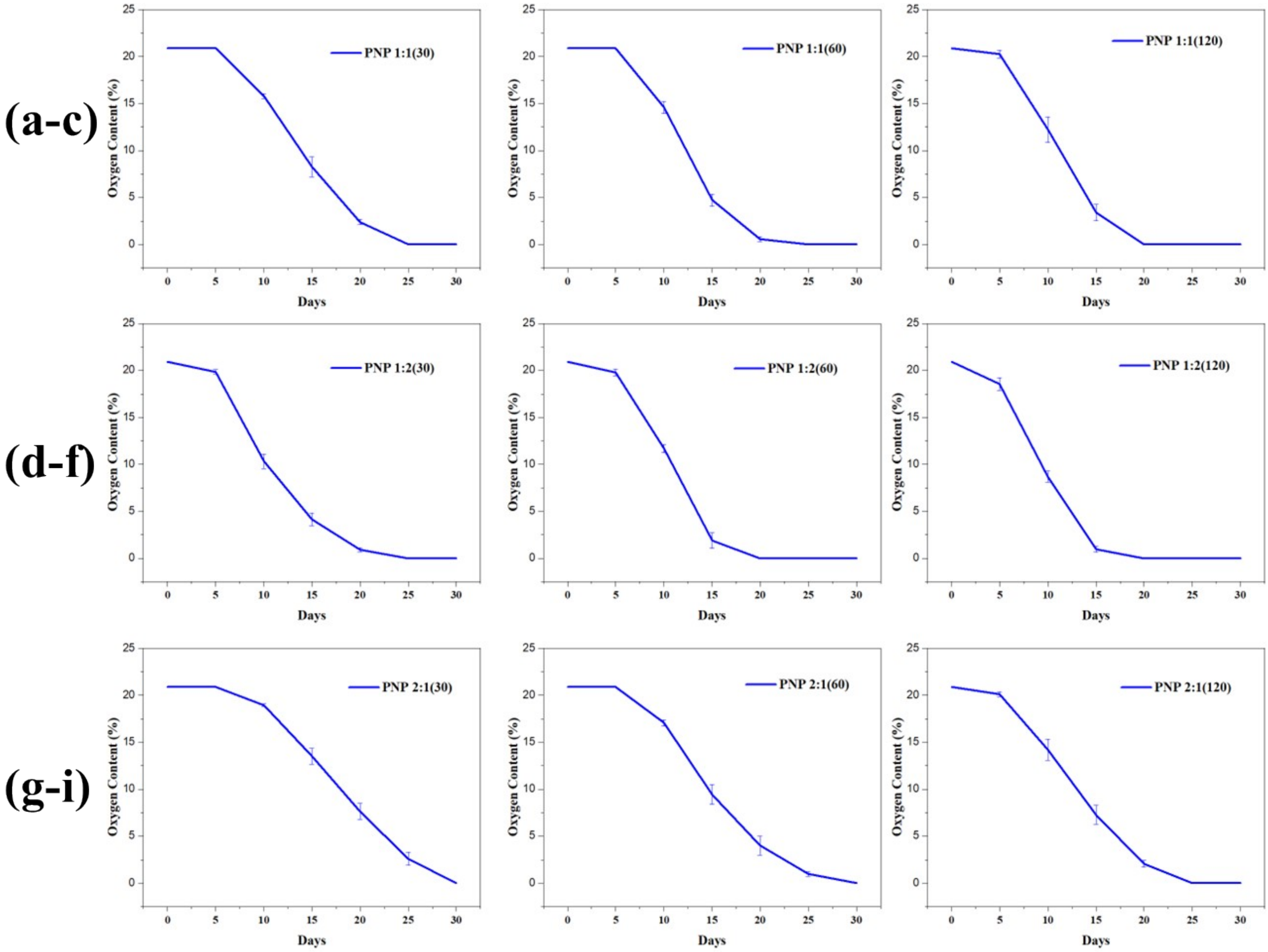

Fig S2. Schematic representation of oxygen scavenging content reduction in the glass vials by the developed polyvinyl alcohol-natural rubber-based films at 25 °C, where PNP 1:1 (30) means PNP 1:1 at 30 s of UV light exposure time

Supporting Information

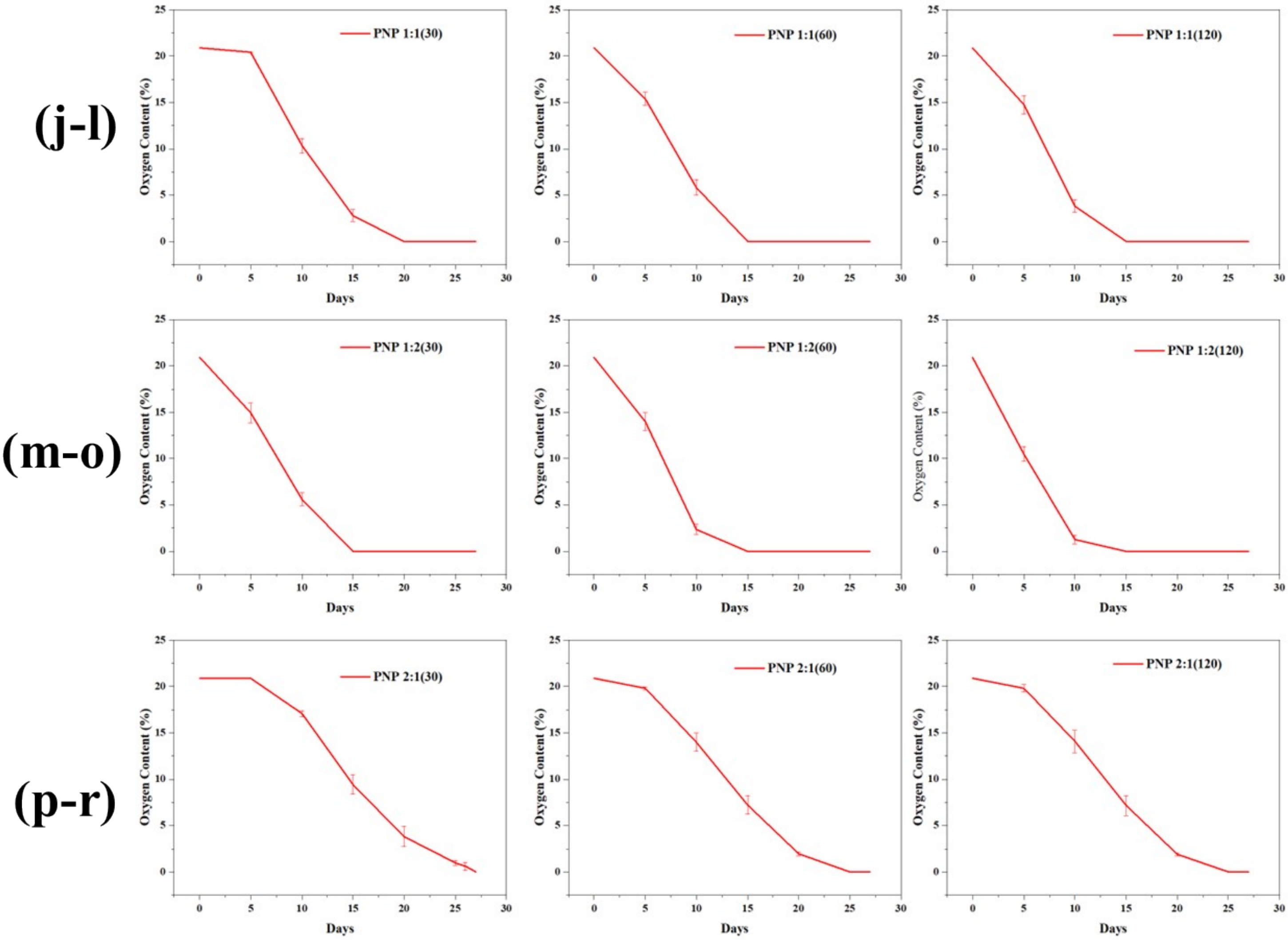

Fig S3. Elucidation of oxygen scavenging content reduction in the glass vials by the developed polyvinyl alcohol-natural rubber-based films at 60 ℃, where PNP 1:1 (60) means PNP 1:1 at 60 s of UV light exposure time

Supporting Information

Supporting Information

Table S2. A comparative study of oxygen scavenging capacity, tensile strength, and biodegradability of the existing and present development

Oxygen scavenging System	Active material	Base materials	Oxygen scavenging capacity (mL O_2/g)	Tensile Strength (MPa)	Biodegradable (Yes/No)	References
Polybutylene adipate-co-terephthalate (PBAT)or Polybutylene succinate (PBS)/Gallic Acid	Gallic acid	Polybutylene adipate-co-terephthalate (PBAT) or Polybutylene succinate	13.70	10.70	Yes	[1]
Thermoplastic starch/ Gallic acid/ Linear low-density polyethylene (LLDPE)	Gallic acid	Thermoplastic starch /Linear low-density polyethylene	20.60	11.00	No	[2]
Low-density polyethylene-ethylene vinyl alcohol-polyethylene terephthalate (LDPE/EVOH/PET)-based films containing β-carotene (CAR)	β-carotene	Low-density polyethylene-ethylene vinyl alcohol-polyethylene terephthalate (LDPE/EVOH/PET)	1.70	NA	No	[3]
Chitosan/Gallic acid/sodium carbonate	Gallic acid	Chitosan	19.55	8.45	Yes	[4]
Low-density polyethylene (LDPE)/ Sodium ascorbate (SA)	Sodium ascorbate	Low-density polyethylene (LDPE)	NA	5.09	No	[5]
Whey protein isolate (WPI) film incorporating ascorbic acid (AA)	Ascorbic acid	Whey protein isolate (WPI)	35.60	3.50	Yes	[6]
Thermoplastic starch (TPS)/Ascorbic acid (AA)- Iron powder	Ascorbic acid (AA)-iron powder	Thermoplastic starch (TPS)	13.50	3.50	Yes	[7]
Low-density polyethylene (LDPE)/Natural Rubber	Natural rubber	Low-density polyethylene (LDPE)	61.00	9.21	No	[8]

PVA/Natural rubber latex/photocatalytic system	Natural rubber latex	Polyvinyl alcohol (PVA)	1045	56.80	Yes*	Present work

*Present work achieved up to 88% biodegradability within 90 days

Bond Energies

Usually, allylic C-H bond has lower bond dissociation energy when compared to tertiary (°3) C-H bond in alkane hydrocarbons (~85 & ~90-103 kcal/mol for prior and latter, respectively) and vinyl C-H bond dissociation energy (~105 kcal/mol). The oxygen scavenging reactions can be rapid if the bond formed (ROO-H) is at least as strong as the bond dissociated R-H [9].

Supporting Information

References

(1) Sonchaeng, U.; Promsorn, J.; Bumbudsanpharoke, N.; Chonhenchob, V.; Sablani, S. S.; Harnkarnsujarit, N. Polyesters Incorporating Gallic Acid as Oxygen Scavenger in Biodegradable Packaging. *Polymers 2022, Vol. 14, Page 5296* **2022**, *14* (23), 5296. https://doi.org/10.3390/POLYM14235296.

(2) Promsorn, J.; Harnkarnsujarit, N. Oxygen Absorbing Food Packaging Made by Extrusion Compounding of Thermoplastic Cassava Starch with Gallic Acid. *Food Control* **2022**, *142*, 109273. https://doi.org/10.1016/J.FOODCONT.2022.109273.

(3) Juan-Polo, A.; Maestre Pérez, S. E.; Monedero Prieto, M.; Sánchez Reig, C.; Tone, A. M.; Herranz Solana, N.; Beltrán Sanahuja, A. Oxygen Scavenger and Antioxidant LDPE/EVOH/PET-Based Films Containing β-Carotene Intended for Fried Peanuts (Arachis Hypogaea L.) Packaging: Pilot Scale Processing and Validation Studies. *Polymers 2022, Vol. 14, Page 3550* **2022**, *14* (17), 3550. https://doi.org/10.3390/POLYM14173550.

(4) Singh, G.; Singh, S.; Kumar, B.; Gaikwad, K. K. Active Barrier Chitosan Films Containing Gallic Acid Based Oxygen Scavenger. *Journal of Food Measurement and Characterization 2020 15:1* **2020**, *15* (1), 585–593. https://doi.org/10.1007/S11694-020-00669-W.

(5) Modaresi, A. S.; Niazmand, R. Characterization of Oxygen Scavenger Film Based on Sodium Ascorbate: Extending the Shelf Life of Peanuts. *Food and Bioprocess Technology 2021 14:6* **2021**, *14* (6), 1184–1193. https://doi.org/10.1007/S11947-021-02631-0.

(6) Janjarasskul, T.; Tananuwong, K.; Krochta, J. M. Whey Protein Film with Oxygen Scavenging Function by Incorporation of Ascorbic Acid. *J Food Sci* **2011**, *76* (9), E561–E568. https://doi.org/10.1111/J.1750-3841.2011.02409.X.

(7) Mahieu, A.; Terrié, C.; Youssef, B. Thermoplastic Starch Films and Thermoplastic Starch/Polycaprolactone Blends with Oxygen-Scavenging Properties: Influence of Water Content. *Ind Crops Prod* **2015**, *72*, 192–199. https://doi.org/10.1016/J.INDCROP.2014.11.037.

(8) Pawde, S.; Chaudhari, S. R.; Prabhasankar, P.; Matche, R. S. LDPE-Natural Rubber Composite Film as Active Packaging: A Paradigm Shift in Oxygen Scavengers. *ACS Appl Mater Interfaces* **2023**, *15* (32), 38729–38740. https://doi.org/10.1021/ACSAMI.3C05168/ASSET/IMAGES/LARGE/AM3C05168_0005.JPEG.

(9) Li, H.; Tung, K. K.; Paul, D. R.; Freeman, B. D.; Stewart, M. E.; Jenkins, J. C. Characterization of Oxygen Scavenging Films Based on 1,4-Polybutadiene. *Ind Eng Chem Res* **2012**, *51* (21), 7138–7145. https://doi.org/10.1021/IE201905J/ASSET/IMAGES/LARGE/IE-2011-01905J_0001.JPEG.