

Anti-Soiling and Anti-Reflective Properties of a Mechanically Durable Coating for Solar Glass

Carmen Wang^{1,2}, Madupa Abeywardena^{1,2}, QianFeng Xu³ and Alan Lyons^{1,2,3}

¹Ph.D. Program in Chemistry, The Graduate Center of the City University of New York, 365 Fifth Avenue, New York, NY 10016

²Department of Chemistry, College of Staten Island, City University of New York, Staten Island, New York 10314

³ARL Designs LLC, New York, NY 10027

Accumulation of soiling is the primary reason for decreased efficiency of field deployed photovoltaic (PV) solar panels. The direct loss of energy output, as well as the corresponding indirect cost of frequent cleaning and maintenance due to soiling, increases the levelized cost of electricity (LCOE) from PVs. To reduce costs, anti-soiling coatings have been widely studied. Field tests have shown, however, that the coatings remain effective for only a limited time (≤ 2 years) and under certain weather conditions; thus, active cleaning is still necessary. However, anti-soiling coatings tested to date are too thin and/or soft and so are rapidly abraded away. A more feasible approach to mitigate soiling is to develop an anti-soiling coating that is mechanically durable and easy-to-clean, so that maintenance costs can be minimized.

To develop an abrasion-resistant hydrophobic coating that maintains performance for ≥ 20 years in the field, our group is taking two approaches to increase abrasion resistance while maintaining hydrophobicity and optical clarity. In the first approach, we are developing a densely cross-linked hydrophobic matrix that is hard and abrasion resistant. In the second approach, the coating is reinforced with nanoparticles randomly dispersed within the matrix to further increase abrasion resistance. The coating will be assessed by UV-vis spectroscopy for measuring % transmittance values and the uniformity of the coating. Abrasion resistance will be measured using a Taber reciprocating abrasion instrument. The anti-soiling performance of the coating will be evaluated using the existing soiling and cleaning chambers in our laboratory to simulate real-world environmental conditions. To date, our group has made significant progress in developing transparent, abrasion-resistant hydrophobic coatings that has potential for outdoor testing for PV applications. The coatings have demonstrated the ability to maintain their abrasion resistance, hydrophobicity, and optical properties after 2,000 abrasion cycles.

References

[1] Abeywardena, M.; Zimmermann, T.; Xu, Q.F.; Löbmann, P.; Mandel, K.; Stauch, C.; Lyons, A.M., Enhanced self-cleaning performance on hydrophobic glass surfaces using hydrophilic dagger features coated with silica nanoparticles, *Solar Energy Materials and Solar Cells*, 2025, 282, 113366, <https://doi.org/10.1016/j.solmat.2024.113366>.

[2] Newkirk, J.M.; Nayshevsky, I.; Sinha, A.; Law, A.M.; Xu, QF; To, B; Ndione, PF; Schelhas, L.T.; Walls, J.M.; Lyons, A.M.; Miller D.C., Artificial linear brush abrasion of coatings for photovoltaic module first-surfaces, *Solar Energy Materials and Solar Cells*, **2021**, 219, p. 110757.

[3]. Nayshevsky, I.; Xu, Q.F.; Newkirk, J.M.; Furhang, D.; Miller, D.C.; Lyons, A.M., Self-cleaning hybrid hydrophobic-hydrophilic surfaces: durability and effect of artificial soilant particle type, *IEEE J. Photovoltaics*, **2020**, 10, p.577-584. <https://doi.org/10.1109/JPHOTOV.2019.2955559>.

