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Assessment of different chemical compounds for EVA delamination

Xinyi Zhang[1], Zhili Teh[1], Robert Patterson[1], Jose Bilbao[1]

[1]*School of Photovoltaic and Renewable Energy Engineering, The University of New South Wales Sydney 2052, Australia*
E-mail: xinyi.zhang@student.unsw.edu.au

The recycling of PV modules has been identified as one of the main challenges that the PV industry is facing now, in order to achieve terawatts of capacity while keeping low environmental impacts (IRENA, 2016). However, one of the most challenging problems in the recycling process of PV modules is the delamination of its components. Although several recycling processed have been developed since early 2000's (Klugmann-Radziemska and Ostrowski, 2010)(Park *et al.*, 2016), with some available at commercial level (PV CYCLE, 2015), they rely on mechanical downcycling processes that can reclaim materials with a fraction of their original value. Hence, the recovery of intact module contents in order to maximise the value of the materials reclaimed, requires the careful delamination of PV modules and its components. Currently, there are two promising approaches to achieve this type of delamination: thermal and chemical treatments. This paper presents the experimental results that were performed to study the delamination of PV modules using a **chemical treatment**, particularly focused on separate module layers through swelling and dissolving of the EVA (ethylene vinyl acetate) encapsulant.

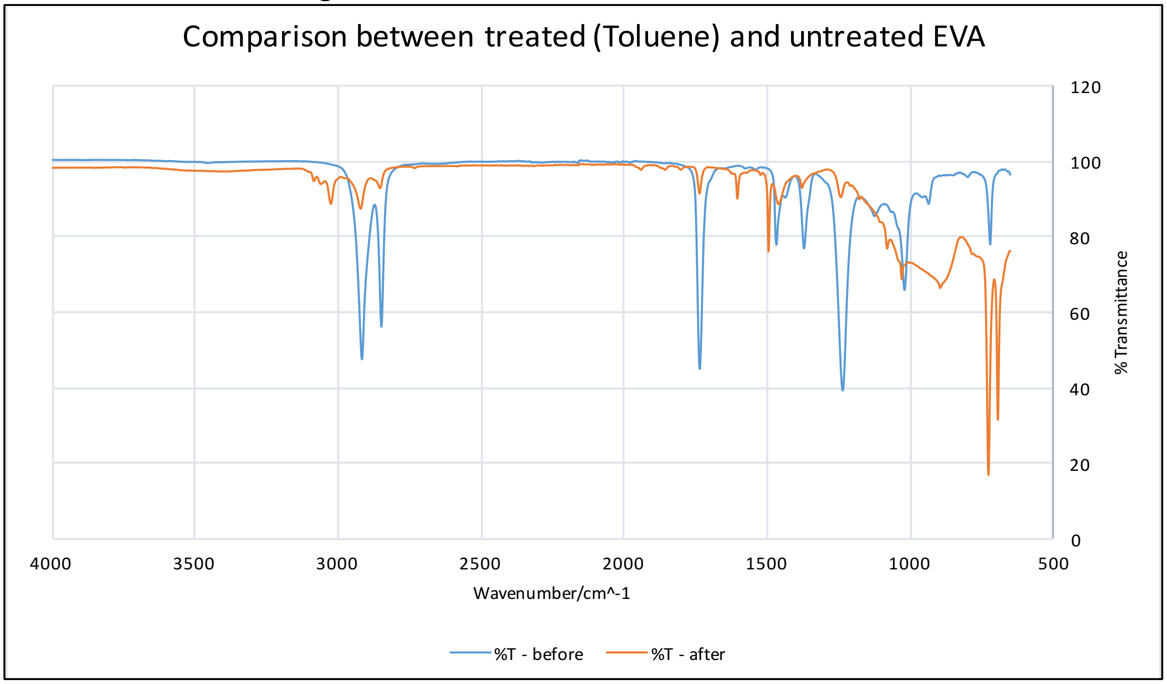
Table 1. Polarity of tested organic solvents

Hydrophilic - Polar	Hydrophobic - Non-polar
Acetone	Lacquer thinner
Ethanol	Toluene
Isopropanol	Petroleum benzine
Methyl ethyl Ketone	1,2-Dichlorobenzene
Methyl isobutyl Ketone	Tetrahydrofuran
Ethylene glycol	Trichloroethylene

Several organic solvents have been tested by other research groups (Doi et al., 2001) and only a few were able to 'react' with EVA which leads to module delamination. No specific criteria for the solvents selection or a reaction mechanism was discussed in that work. In our study, the underlying mechanism of how organic solvents interact with EVA extents was analysed based on the chemical structure of EVA molecules. Table 1 has categorized all the organic solvents that have been tested into 2 categories based on their polarity. Although EVA has both polar and non-polar molecules, the organic solvents that can interact' with EVA, highlighted in green colour, all fall into the non-polar category. Thus, we suggest that non-polar organic solvents should be applied when conducting experiments related to dissolving of EVA.

When EVA was treated with toluene and 1,2-Dichlorobenzene, module delamination was successfully achieved with EVA swelling and de-adhering after placing a mini-module (5x5cm) into 100ml of solvent for 24 hours at room temperature, 20℃. The glass and backsheet were recovered clean and intact. This may be the only way to recycle PV module backsheet since the Tedlar backsheet is considered not to be recyclable currently. However, the cell was broken due to the swelling of EVA and mechanical stress from the backsheet. An FTIR (Fourier-transform infrared) spectroscopy measurement was carried out on EVA samples treated with different organic solvents to determine any potential bond breakage or structural changes. Figure 1 shows several significant peak reductions around 3000 cm^{-1}(C-H), 1737 cm^{-1}(C=O), and 1238 cm^{-1}(C-O) indicating those bonds were likely broken during reaction and dissolution. The increase in peaks below 1000 cm^{-1} also explained the swelling of EVA was due to the absorption of solvent, as these peaks correspond to absorbed solvent in the delaminated EVA measured.

Figure 1. FTIR of EVA treated with toluene



As a result, breakage of cell was unavoidable if the EVA was swollen instead of immediately dissolved during the solvent treatment. To resolve this issue, testing is ongoing using different organic solvents and solvent mixtures to find an optimal recipe. Also, a combination of thermal treatment and organic solvents will be examined, in which a module is exposed to high temperature first to partially degrade the EVA before reaching the threshold of cell breakage due to volatile gas production and then dissolution of the EVA with common chemicals may become possible.

Meanwhile, based on the difficulties and limitations met during the delamination process, some suggestions for improving the recyclability of the PV module have been made for the future potential module design, such as finding a new encapsulant material that can be dissolved with common chemicals would make the recycling of PV modules become more economic and environmentally friendly.

References

Doi, T. *et al.* (2001) 'Experimental study on PV module recycling with organic solvent method', *Solar Energy Materials & Solar Cells*, 67, pp 397-403.

Klugmann-Radziemska, E. and Ostrowski, P. (2010) 'Chemical treatment of crystalline silicon solar cells as a method of recovering pure silicon from photovoltaic modules', *Renewable Energy*, 35(8), pp. 1751–1759.

Park, J. *et al.* (2016) 'An eco-friendly method for reclaimed silicon wafers from a photovoltaic module: from separation to cell fabrication', *Green Chem.* Royal Society of Chemistry, 18(6), pp. 1706–1714.

Weckend, S., Wade, A. and Heath, G. (2016) *End-Of-Life Management Solar Photovoltaic Panels*.