# ANTI-SOILING COATINGS FOR PV MODULES

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ABSTRACT: Application of large scale photo-voltaic installations in remote desert regions – such as the Middle East and North Africa (MENA) faces a number of challenges: high operating temperatures and UV dose are well known conditions to take into account in view of product lifetime. On top of that yearly yields are under pressure by a phenomenon known as soiling, a process in which dust permanently settles on surfaces in regions with low amounts of rainfall (though moisture is present). Dust built up by the specific interaction with moisture, a process called cementation, results in a layer which is hard to remove and which can cause a dramatic loss in light transmission and consequently results in a drop in yearly yield (up to tens of percent's).
Mitigation strategies to counter this problem include (frequent) manual or automatic cleaning and preventive measures like anti-soiling coatings. The latter solution would in the ideal case completely prevent soiling. In this study effectiveness and durability of several anti-soiling coatings is reported, using a reproducible method for accelerated soiling under laboratory conditions. For durability testing, the focus has been towards abrasion resistance to simulate the harsh conditions specific for the MENA region (sand storms and dust).
Keywords: Desert Application, Soiling, Abrasion, Qualification and Testing, System Performance

## 1 INTRODUCTION

Desert regions are attractive for harvesting solar energy since average irradiation levels can be very high, up to 2.5 times the irradiation in north-west Europe. Unfortunately deposition of dust onto solar active devices (either photo-voltaics (PV) or thermal) substantially compromises yearly yields. For PV applications losses due to soiling have been reported of up to several tens of percent [1]. Since PV power plants require a substantial amount of space it is interesting to install large PV power plants in remote regions with low area related costs. However cleaning is likely to be a cost factor in that case (due to the need for transportation of water, cleaning equipment and manpower). Attractive mitigation strategies against soiling are those that do not require any human interference during long periods, by using specific coatings for example. Since desert climates can be defined as harsh when it comes to UV dose, temperature and sand storms, the requirements for durable coatings are difficult to meet. Recently, interest in testing the effectiveness and durability of anti-soiling (AS) coatings is growing [3]. Up to today, a standard for applying soiling or testing the abrasion resistance for PV application of such coatings is still lacking.

Anti-soiling coatings are offered commercially by a growing number of suppliers. Specific requirements for application in PV are high transmission characteristics and durability. The latter should be taken not only as defined in specific PV oriented IEC standards (damp heat and thermal cycle) but also regarding abrasion resistance. In this study the focus has been directed towards testing the effectiveness of AS coatings by developing a fast soiling method and measuring the amount of soiling which sticks to the AS coated glass. The abrasion resistance of AS coatings is evaluated according to the more general standards for window glass [2]. Both the effectiveness and abrasion resistance has been determined for AS coatings obtained from different suppliers.

## 2 APPROACH

The anti-soiling coatings of interest have been either provided as a coating already present on a glass substrate or as a solution to be applied onto a pre-cleaned glass plate. In the latter case tempered glass for PV applications has been used to apply the coating following the methods prescribed by the coating supplier.

Part of the coated glass surface has been subjected to abrasion testing prior to covering the substrate with artificial soiling material. After drying the soiling was removed by pulling it off with adhesive tape, allowing for observation of the degree of removal the soiling material and assessment of the anti-soiling properties in a qualitative way based on visual inspection. The abrasion testing has been conducted according to EN 1096-2 [2].

By means of a felt rubbing setup (Fig.1) a felt pad is moved a number of times across the surface to be evaluated. Different pass criteria exist for coatings on glass depending on field of application (indoor or outdoor), normally based on measured changes in transmission. For this study the (mostly large) visual changes upon abrasion of a sample have been used as a guideline.


**Figure 1:** Felt rubbing test setup

## 3 RESULTS AND DISCUSSION

Table I shows the relative ranking of 3 representative anti-soiling coatings tested for effectiveness and resistance towards abrasion. Sample 1 is an example of an initially well performing coating, which loses its activity after minor abrasion testing (although more than prescribed according to standard EN 1096-2).

Sample 2 did not reveal any anti-soiling activity better than uncoated glass.

Sample 3 revealed an excellent anti-soiling activity both at initial state and after severe abrasion testing (> 10000 strokes).

**Table I:** Ranking of 3 different anti-soiling coatings with respect to effectiveness and abrasion resistance

| sample | AS activity | AS activity |
|---|---|---|
| | initial | after abrasion |
| | | (no. of strokes) |
| 1 | ++ | - (500-1000) |
| 2 | -- | No test |
| 3 | ++ | ++ (>10000) |
| | | |
| | ***Legend AS activity ranking*** | |
| | -- | non visible |
| | - | low |
| | + | good |
| | ++ | excellent |

Figure 2 shows a sample (no. 1) on which an anti-soiling coating has been deposited (as received from an external supplier). Three marked zones can be distinguished on the test surface.

1. In red: The area where abrasion testing was conducted prior to artificial soiling of a larger part of the sample (all white parts).
2. In green: Area where no abrasion testing was conducted prior to soiling.
3. In black: Area where all loosely adhering material has been removed by pulling off with adhesive tape.

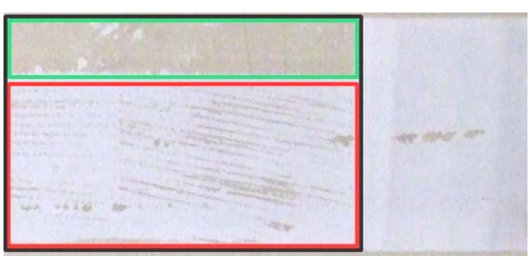

**Figure 2:** A glass sample (no. 1) with anti-soiling coating after 1. abrasion testing, 2. Soiling (white material) and 3. removal of loosely adhered soiling material (successful within the green zone predominantly)

From Figure 2 it can be derived that only soiling material deposited in the green zone, where no abrasion test has been applied, could be removed effectively by tape pulling. On the part where abrasion testing has been conducted (red) prior to soiling the adherence of this material to the glass is significantly increased. This indicates the anti-soiling coating has been deactivated or has completely disappeared by the abrasion test (500 strokes).

Figure 3 shows a glass sample with another anti-soiling coating (sample no. 3).

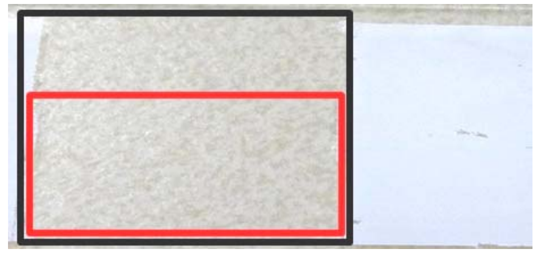

**Figure 3:** A glass sample (no. 3) with anti-soiling coating after abrasion testing (> 10000 strokes), soiling (white material) and removal of loosely adhered soiling material

For sample no. 3 it is not possible to distinguish between the abrasion zone (red) and untouched area after pulling off the soiling material with tape (within the black lines). It shows the anti-soiling coating applied here is still very effective after intense abrasion testing (> 10000 strokes).

## 4 CONCLUSIONS

A number of commercially available anti-soiling coatings has been tested for effectiveness regarding self-cleaning properties and abrasion resistance. A fast and practical approach for artificial soiling has been developed. This method combined with abrasion according to a defined standard provides an attractive semi-quantitative test for assessment of anti-soiling coatings. The properties of the coatings tested vary considerably, in particular with respect to abrasion resistance. The latter parameter ranges from < 500 strokes to > 10000 strokes before the effect of abrasion on the coated surface becomes visible, i.e. a range spanning at least a factor 20 between the best and worst performing coatings.

We conclude that it is very important to study both the initial performance and the durability of anti-soiling coatings. The effects on PV power production in the field needs to be further quantified.

The outcome of this type of research should serve as an input for further development and selection of robust anti-soiling coatings enabling cost effective deployment of large scale PV in desert regions.

## REFERENCES


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