A progress report for the Latvian Council of Science project conducted within the Fundamental and applied research projects framework "*Engineered surface platform for immobilization of microorganisms*" (lzp-2018/1-0460) on the work done during the 01.06.2018. – 01.09.2019. time frame

The report includes progress information on the following tasks:

- Determination of optical wavelengths or wavelength combinations to promote electrical charge accumulation on the surfaces of both immobilization platforms and satellite samples
- Determination of the optimal exposure time and light intensity for the promotion of prolonged surface charge retention
- Development of new approaches for the studies of immobilized yeast cells

Achieved results

Electrical charge promotion through irradiation with UV light

Deposition of electrical charge was performed using the full spectrum of a HAMAMATSU LIGHTNINGCURE LC8 UV light source. Irradiation was performed in an enclosed environment that was sterilized with 96% ethanol before samples were placed inside of it. The temperature and the relative humidity during irradiation are maintained at 22±1 ^{o}C and 30±5%, respectively. These conditions were supplied by the air conditioning system of the facility. Dose was varied by using different exposure times from zero to 75 minutes. Distance from the light source to the sample was maintained at 20 centimeters for each sample. The samples were placed in the same intensity region during every exposure. For each dose four randomly selected satellite samples were used, and each sample was irradiated individually. A total of 20 samples were used.

PE spectra were acquired for SiO_2 satellite samples before and after exposure to UV radiation. After irradiation the samples were immediately transferred into the vacuum chamber of the photoelectron emission spectrometer. Spectra were taken 15 minutes after placing the samples into the chamber due to vacuum pumping time. The spectral range of the measurements was 300 to 200 nm with a rate of 1 nm/s. Work function values for all samples were determined as above. Minimum work function values were recorded at 30 min exposure time (4.76 ± 0.02 eV, difference from initial value – -0.08 eV), maximum work function values were recorded at 60 min exposure time (4.87±0.02, difference from initial value – +0.03 eV). Because these doses provided the most variation in work function values, they can be selected to be applied to the micropatterned samples and used during cell deposition experiments.

PE spectra were acquired also for 6 types of microstructured samples before and after exposure to UV radiation using the 30-minute exposure time and the 60-minute exposure time. From each of the six sample groups four samples were selected randomly for each exposure time giving a grand total of 48 samples. Measurements were performed in one spot for each sample. After 30-minute exposure to UV irradiation work function values for all micropatterned samples fell within 4.36 ± 0.02 eV (difference from initial value – -0.11 eV). After 60 min exposure to UV irradiation work function values fell within 4.59 ± 0.02 eV (difference from initial value – +0.12 eV). It seems that micropatterned samples react more sharply to exposure to UV radiation than the satellite samples.

FTIR absorbance spectra were acquired only from satellite samples which were irradiated with UV light. One measurement was performed per sample. A total of 20 spectra were acquired as described above. The spectra were averaged out for each exposition time; these resulting spectra are given in Figure 2.

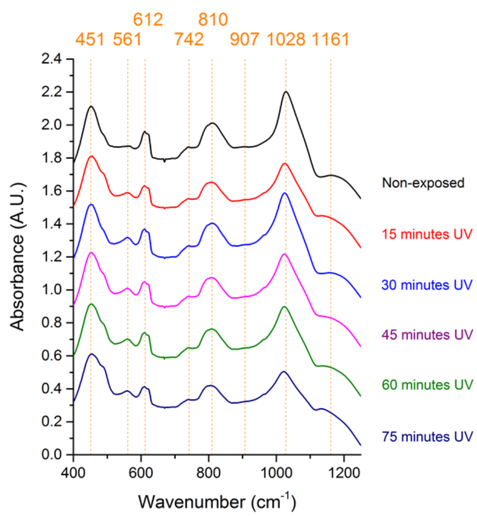

Figure 1. *ATR FTIR absorbance spectra on satellite samples exposed to UV radiation for different time periods. Each spectrum is offset from the previous one by 0.3 A.U. for convenience.*

All the absorption peaks that were observed for non-irradiated samples are present in spectra of irradiated samples. The intensity of most peaks, except for the Si-O-Si bend peak at 452 cm^{-1}, changes substantially after irradiation. The absorption peak at 564 cm^{-1} became much more pronounced after irradiation with UV light, as did the bump on the downwards slope of the 452 cm^{-1} peak. The wavenumber for the out-of-phase Si-O-Si asymmetric stretching peak shifted downwards from about 1160 cm^{-1} to about 1135 cm^{-1} after 75-minute exposure to UV radiation. The 1028 cm^{-1} peak that corresponds to the in-phase Si-O-Si asymmetric stretching also displays a slight variance in wavenumber. All in all, it does not seem that UV irradiation at the given doses – except for the 75-minute exposure – does not influence the integrity of chemical bonds. Therefore, the exposures time below 75 minutes can be used for charge deposition.

KPFM measurements were performed as above on two out of seven types of micropatterned samples that were exposed to UV radiation for 30 and 60 minutes. Four samples were randomly selected from each irradiated group. For samples that were irradiated for 30 minutes the average surface potential value measured at the plateaus was 4.65±0.05 V and at the valleys was 4.5±0.2 V. For samples that were irradiated for 60 minutes the average surface potential value measured at the plateaus was 4.71±0.07 V and at the valleys was 4.76±0.04 V. A graphical representation of the results can be seen in Figure 3. The results demonstrate two distinct trends: a) the surface potential of valleys increases gradually with an increase in dose and b) the surface potential of plateaus decreases with 30 minutes of exposure and increases with 60 minutes of exposure. The difference in potentials of valley and plateaus can relate to the distinction of the oxides: the valley is coated with a thin natural oxide layer in contrast to the plateaus coated with a thick technologically grown oxide layer.

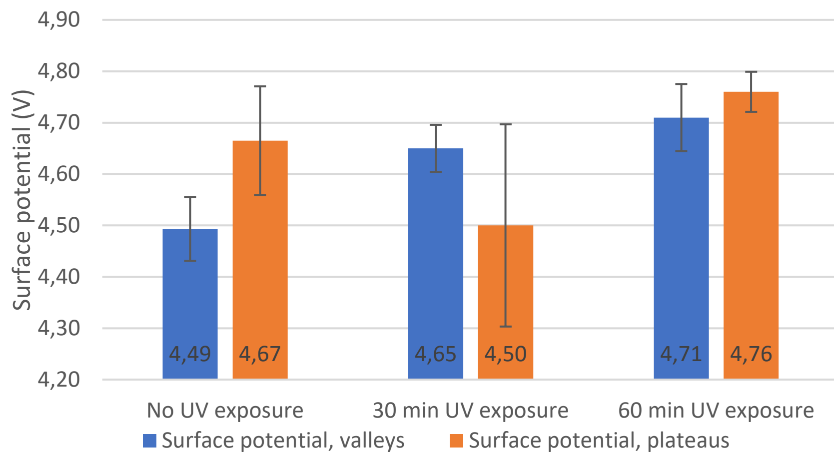

Figure 2. *Surface potential of different regions after exposure to UV radiation as measured by AM-KPFM.*

Surface charge retention studies

A method for probing incident light induced charge/discharge phenomena on the surfaces of materials in real time was developed. Measurements were performed on valley and plateau surfaces.

Conclusion

30- and 60-minute exposure times show promise as they produce the largest changes in the surface potential values of the samples. Therefore, these exposure times will be used to charge up immobilization platforms throughout this study.

A method for studying light induced charge accumulation has been developed. It was measured that charge retention is better for plateaus.