The use of thermally stimulated luminescence for rapid assessment of plasma treated particulate materials

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Thermally induced light emission (luminescence) is presented as a particularly suitable tool for monitoring the level of plasma surface activation. The method is relatively fast, exhibits a surprising sensitivity and allows evaluation of even poorly defined surface, which are typical for particulate materials. The examples of three distinct materials are presented – plasma activated PET flakes, cellulose fibres pulp and Al_2O_3 powders.

1. Introduction

The processing of particulate materials (i.e. substances consisting of individual particles) plays a key role in the number of industrial sectors, e.g. ceramic and coatings engineering, pharmaceutical, composites or recycling industries. In many cases, the surface of particulate material needs to be modified to achieve better interaction with given liquid matrix, e.g. solvent or binder. For that, non-thermal plasma treatment (PT) of particles surface may be a suitable choice, chiefly due to its low environmental impact. The vexing problem associated with PT of particulate materials is its problematic transport through the active plasma zone. For instance, fine powders are attached to the electrodes by electrostatic charging, or blown off by the ion wind. These effects cause a poor control on the average PT time of material. Larger particles, such as polymer flakes or wood pulp, suffer from their irregular shape, which increase the risk of insufficient PT at short treatment times. A suitable diagnostic tool allowing rapid assessment of the level of plasma activation is therefore needed for PT optimization.

2. Results

Thermally stimulated luminescence (TSL) experiments were performed on the photon-counting instrument Lumipol 3 (SAS, Bratislava), which detected the spectrally unresolved VIS light emission upon controlled sample heating up to 300°C. The PT was done using the diffuse coplanar dielectric barrier discharge (DCSBD) operated in atm. pressure air.

PET flakes with average size of 2.25×17.7mm were PT for 60 sec to achieve better mechanical properties particleboards made from PET and wood particles [1]. Immediately after the treatment, the PT flakes exhibited 10-fold increase of peak TSL intensity. The cross-check XPS analysis confirmed higher number of oxygen containing surface group. Therefore the chemiluminescence (originating from the recombination of peroxy and hydroperoxy radicals) is most likely detected by TSL.

Cellulose fibre pulp (GREENCEL, Slovakia) was PT to promote its further silanization. TSL measurements showed 2-fold signal increase, while the changes in XPS or FTIR spectra were not that dramatic. Although TSL signal was ambiguous to interpret, it proved again to be a sensitive PT indicator.

Finally the submicron Al_2O_3 powders were PT to enhance their dispersion stability [2]. PT treatment resulted in more than 15-fold rise of TSL signal. Our further analysis indicated that observed TSL signal is that of thermoluminescence – originating from electrons relaxed from the Al_2O_3 trapped states, populated during the previous PT.

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4. References

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