UV Absorption and Multi-angle Light Scattering Detector System for Nanoparticle Analysis

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We report on the final integration of a UV absorption and Multi-Angle Light Scattering (MALS) detector system for the detection of nanoparticles in liquid suspensions. The advantages of the detector system are the compact optical design, the high sensitivity and the cost-effective and easily replaceable flow-through cartridges. The system was demonstrated with in-line measurements of liquid samples containing various nanoparticles.

Previously, we reported on the development of UV absorption and Multi-Angle Light Scattering (MALS) prototype systems, developed in the framework of the ongoing EU-FP7 project SMART-NANO (see CSEM Scientific Report 2014 and 2013). In the last year, the two prototype detectors were further developed and combined into a single detection system.

The improvements of the MALS detector covered both hardware and software aspects. To reduce the costs of the system, the solid state laser used in the previous prototype was replaced by a diode laser and the optical chopper was removed. Instead of the optical chopper, the diode laser is now modulated electronically. This resulted in a more robust system with no moving parts. The signal to noise ratio of the detector was further increased by removing ground loops in the electronic system. Another improvement is the higher modulation frequency of the laser diode, which increases the signal to noise level of the lock-in amplifier. The flow cell of the MALS system was also improved. The glue-bonded flow cell used in the previous prototype turned out too tricky to handle, leading to leakage in case of pressure increases in the system, or when using organic detergents/surfactants such as sodium dodecyl sulfate (SDS). To solve these problems, the MALS cell was redesigned. The new cell design features a clamped cylinder lens to the mechanical body with a gasket in between. The new design allows the use of organic solvents for cleaning and no leakage due to overpressure occurred.

The UV detector was also further optimized in several aspects. To improve the signal to noise ratio, the photodiode electronics were redesigned and packaged into a Faraday cage. To simplify the handling of the UV detector, an automated optical filter system was installed to reduce the higher order diffraction. In the previous prototype, the filter had to be exchanged manually. Furthermore, the user friendliness was improved by reducing the number of USB connections to the laptop from three connections (analog to digital converter card, monochromator and automated optical filter) to a single one. Figure 1 shows the inside view of the two detectors.

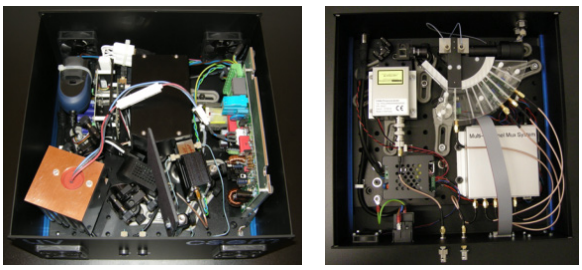

Figure 1: Inside view of the UV (left) and MALS (right) detectors.

For both instruments, a compact housing was designed. The main goals of the housing design was for it to be as small as possible and that the measurement cell be easily accessible/removable without the need to remove any screws. Furthermore, a single GUI (graphical user interface) was developed. The GUI can control both instruments at the same time and show the measured data of the UV- and MALS-detector in the same graph. Finally, the analysis software was also improved in collaboration with the project partners.

Figure 2 shows the complete final system as it was delivered to our project partners.

Figure 2: Complete UV absorption and MALS detector system for nanoparticle analysis. The lock-in system used for MALS detection is visible on the right.

Preliminary calibration measurements were carried out at CSEM to verify the reliable operation of the detector system. The complete system was then delivered to JRC (Joint Research Center) Ispra, a partner in the project for in-depth testing and qualification of the two detectors within standard solutions and engineered nanoparticles (ENP) containing samples developed in the project. The characterization is ongoing. Figure 3 shows a first, preliminary measurement of BSA (Bovine Serum Albumin).

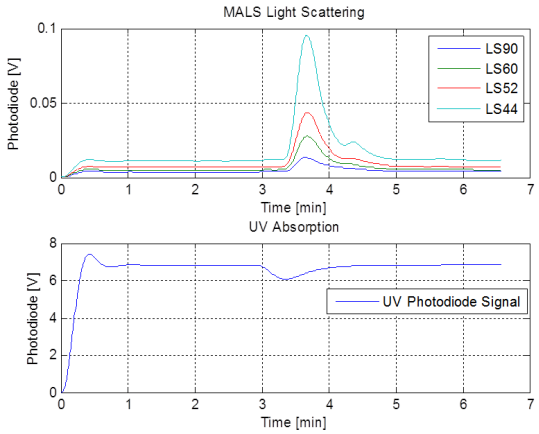

Figure 3: MALS (top) and UV (bottom) signals of BSA protein sample. The MALS data shows the light scattering signals collected at four different angles (90°, 60°, 52° and 44°). The UV data shows the data collected at 280 nm.

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[1] www.smartnano.org