Photophoresis (PP) denotes the phenomenon that small particles suspended in gas (aerosols) [1] or liquid (hydrocolloids) start to migrate when illuminated by a sufficiently intense beam of light. PP motion can occur in the direction of light beam (positive PP) or in the opposite direction (negative PP). In case the particle is transparent and the index of refraction is larger than the one of the surrounding medium, the particle moves away from the light source due to momentum transfer from absorbed and scattered photons. When the particle absorbs the incident light, a temperature gradient is generated which causes the migration according to its thermal and optical properties and is termed Thermo-PP.

In conventional separation techniques, aerosols and colloids are separated by means of electrical, thermal or flow fields. In our approach, the application of light is tested as a means to separate particles due to their optical properties. Such a separation technique would allow e.g. the separation of organic from inorganic particles of the same size. We aim to develop a continuous flow separation system for aerosols regarding the optical properties of the particles [2].

Table 1. Photophoretic properties of differently coloured and sized PSL particles (cross flow setup).

<table>
<thead>
<tr>
<th>Size [μm]</th>
<th>Particle colour</th>
<th>Photophoretic velocities [μm/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.99</td>
<td>white</td>
<td>0.112 ± 0.014</td>
</tr>
<tr>
<td>1</td>
<td>red [606 nm]</td>
<td>0.113 ± 0.018</td>
</tr>
<tr>
<td>1</td>
<td>yellow [514 nm]</td>
<td>0.144 ± 0.014</td>
</tr>
<tr>
<td>1.9</td>
<td>white</td>
<td>0.172 ± 0.025</td>
</tr>
<tr>
<td>2.88</td>
<td>white</td>
<td>0.259 ± 0.034</td>
</tr>
</tbody>
</table>

Table 1 summarizes the observed PP velocities in ascending order for a set of PSL particles differing in size and colour. The experimental system essentially consists of a flow cell with rectangular cross section (1 cm², length 25 mm), where the aerosol stream is pumped through in vertical direction at ambient pressure. Two different configurations were compared, one where the laser beam and hence the PP force is directed orthogonally to the aerosol flow and one, where the PP force and the gas flow counteract in opposite directions. PP force in both cases is generated by a diode laser. Migration of the particles is observed by a CCD camera. From the image series the PP velocities of every single particle is obtained by a special particle imaging velocimetry algorithm.

Experiments with polystyrene lattices (Figure 2) verify the theoretically predicted linear correlation between the particle size and the measured velocities induced by PP. In other experiments we found the same correlation between laser power and PP velocities for a constant particle size. For monodisperse soot particles with a very low thermal conductivity and therefore a high temperature gradient across the particle the highest PP velocities were found. No gradient PP force in radial direction of the laser beam was observed. Therefore, the flow-generated force on the one hand and the PP force on the other hand can be superposed in any desired direction, which allows the construction of a continuous separation system. This work is financially supported by the DFG grant Ni 261/16-1.

1.: Ehrenhaft, F. (1918), Annalen der Physik, 56, 81-132