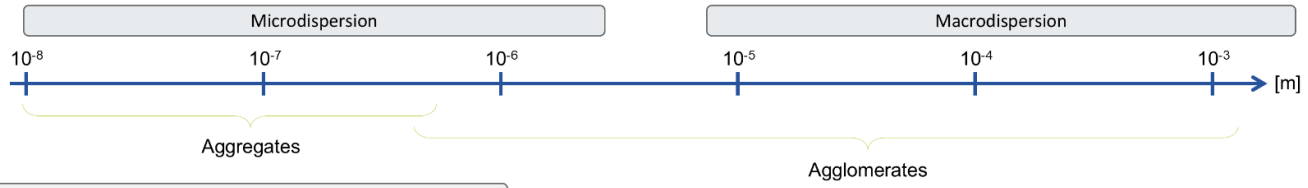
Methods for quantifying the multiscale filler dispersion quality

MATERIALDIGITAL

During the mixing process, fillers are added to the rubber with the aim of improving the mechanical properties of the end product. Since fillers are present as agglomerates, they must be broken up during the mixing process (dispersion), as otherwise they will lead to defects in the compound and thus to a reduced end product performance. The aim of the project is to select a suitable formulation and the associated processing conditions. To achieve this goal, it is essential to consider the dispersion.



TEM analysis of the filler distribution

Dispersion Index Analyse System (DIAS)

Measurement of surface roughness (topography)

TEM analysis of the filler distribution

Sample preparation: Cryo-ultrathin cut

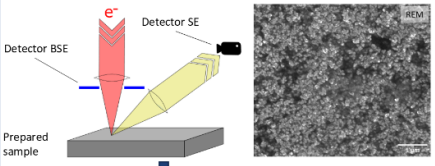
- Cutting thickness (60 to 80 nm) corresponds to to a small number of filler particles → Researching the dependence of the cutting thickness on the results

Functionality:

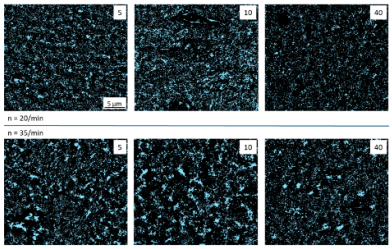
- Illustration of filler distribution at the micro- and nanoscopic scale

Digital image analysis and simulation:

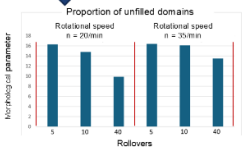
- Determining the size of unfilled domains



Application of new image processing methods for determining the size of unfilled domains in compounds



Calculation of unfilled domains



The size of the unfilled domains decreases with the number of rollovers. At higher rotor speeds, this decrease is less pronounced.

Dispersion Index Analyse System (DIAS)

Sample preparation : Glossy cut

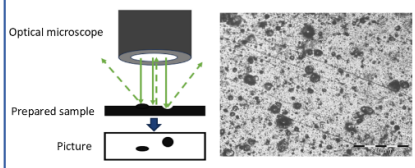
- Filler aggregates and agglomerates are not cut up, resulting in uneven surfaces

Functionality:

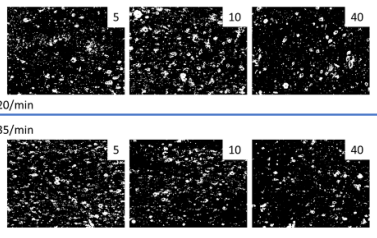
- Good dispersion (flat surface): Light reflection
- Poor dispersion (uneven surface): scattering of the incident light

Digital image analysis:

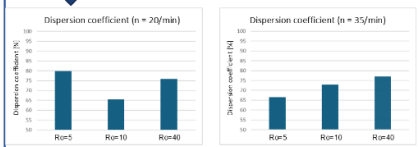
- Calculation of the dispersion coefficient



Application of image processing methods for determining the size of undispersed filler aggregates in compounds



Calculation of the dispersion coefficient



The dispersion coefficient tends to increase with an increasing amount of rollovers. There are deviations from this behavior.

Measurement of surface roughness (topography)

Sample preparation : Glossy cut

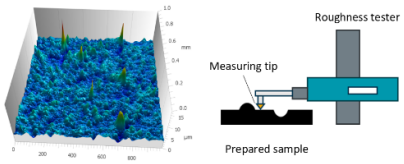
- Filler agglomerates are not cut up, resulting in uneven surfaces

Functionality:

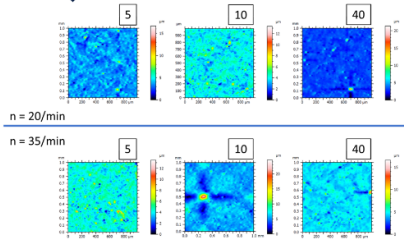
- Tactile measurement of an area of 1 x 1 mm with 201 x 1000 measuring points

Digital image analysis :

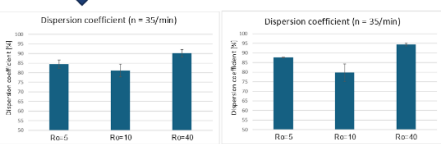
- Calculation of the dispersion coefficient
- Observation of the height distribution of the agglomerates



Application of image processing methods for determining the size of undispersed filler agglomerates in compounds



Calculation of the dispersion coefficient



The dispersion coefficient tends to increase with a large change in the amount of rollovers.

The investigations on the multiscale filler dispersion quality show different results depending on the analysis method and the scale considered. For macrodispersion, it appears that "good" dispersion quality can already be achieved with a short mixing process and is hardly improved by increasing the mixing time. Continuous improvement of microdispersion, on the other hand, results with increasing mixing time. Since both macro- and microdispersion are crucial for the properties of the compound, the investigations show that a multiscale dispersion analysis is essential for mixture optimization.

InSuKa material database

Ein Verbundprojekt von

KIT Karlsruher Institut für Technologie
BAM Bundesanstalt für Materialforschung und -prüfung
Fraunhofer IWM
MAX-PLANCK-INSTITUT FÜR EISENFORSCHUNG GmbH
IWT Leibniz-Institut für Werkstofforientierte Technologien
FIZ Karlsruhe Leibniz-Institut für Informationsinfrastruktur
Bundesministerium für Bildung und Forschung