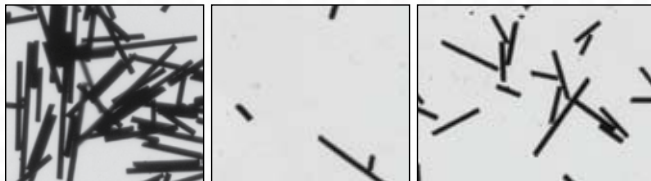


Carbon Fiber Evaluation by Automated Image Analysis

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Figures 1A, 1B, 1C.

The Imaging Challenge

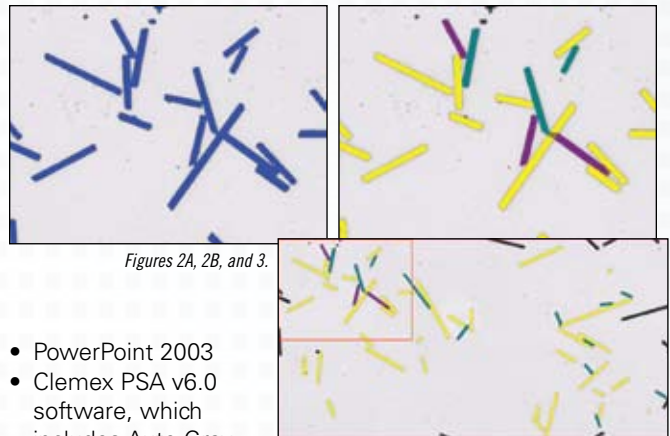
To properly analyze the physical dimensions of carbon fibers with optical microscopy we must have uniform dispersion on the slide. Too many on a slide and it becomes impossible to measure overlapping fibers in clusters; too few fibers on a slide and the results become skewed and non-reliable. The main challenge is to get the greatest number of valid fibers to be recognized and analyzed so that the results become statistically valid (see figures 1A, B and C).

The Solution

The first step is to binarize the black areas with bitplanes that allow us to easily obtain the features we want to measure. Since some long fibers have a good chance of overlapping or of being part of a cluster, isolating them with a separation tool allows us to retain the fibers for statistical purposes instead of eliminating them. Since long objects also have a tendency to spill out of the frame of view. For that reason we implement a Guard Frame that decreases the working area and acts as a safety buffer. Stitching adjacent images together allows us to get the greatest number of valid fibers. Using the Mosaic command from Vision PE, the software controlled motorized stage moves from one Guard Frame to the other, stitching together all relevant fields into one single large image. Once the Mosaic is completed detection, separation, and cleaning of artifacts easily can be performed. The final result shows a significant decrease in sectioned fibers when compared with our original field of view. We used Main Length and Mean Width as starting measurements, then Volume Estimate and Elongation (or Aspect Ratio), these last two were calculated based on the first two measurements. (See Figures 2A, 2B, and 3)

The Tools Used

- Dell Optiplex GX745
- Pentium D CPU 3.40GHz
- Windows XP
- Excel 2007

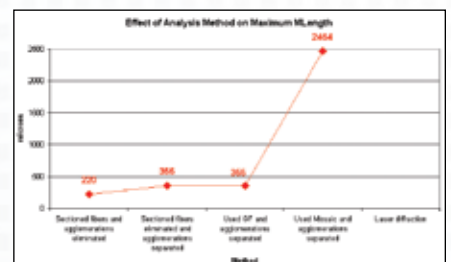
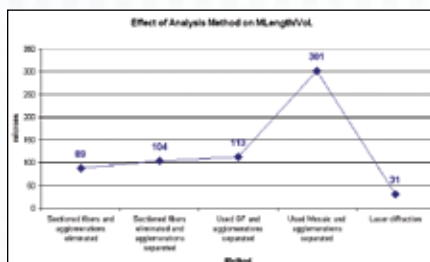


Figures 2A, 2B, and 3.

- PowerPoint 2003
- Clemex PSA v6.0 software, which includes Auto Gray Thresholding Tool
- Split Long Objects Tool, Guard Frame Tool, Mosaic Tool, Measuring Tools
- Clemex L2.1M Camera
- Leica DM-LA Microscope with transmitted light
- Leica CTR-MIC Controller
- Leica N PLAN 10x/0.25 Objective (for a total magnification of 100x and a calibration of 0.6250 microns/pixel)
- Marzhauser 75mm x 50mm Motorized Stage
- Clemex JS-2000 Stage Controller

The Difference it Made

As can be seen, when fibers are eliminated because they are sectioned and whether agglomerations are eliminated or separated, the difference in value is minuscule. Laser diffraction, one of the most common analysis methods, fares no better. Only when the Mosaic image is used do we have meaningful and accurate results. In the second graph below, the line graph looks similar to the previous one, showing that the use of a Mosaic image increases the likelihood of finding and recognizing long fibers. (Figures 4A, 4B)



Figures 4A and 4B.