# SURFACE ANALYSIS OF CARBON & ZEOLITE CATALYSTS USING 3D PROFILOMETRY

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## INTRO:

In order for a catalyst to be effective it must come in direct contact with the reactants, which is why increasing the available surface area of a catalyst directly increases the rate of reaction. In this study, the surfaces of porous catalysts carbon and zeolite are characterized by their surface roughness and developed surface area.

**IMPORTANCE OF 3D NON CONTACT PROFILOMETER FOR PITTING STUDY**

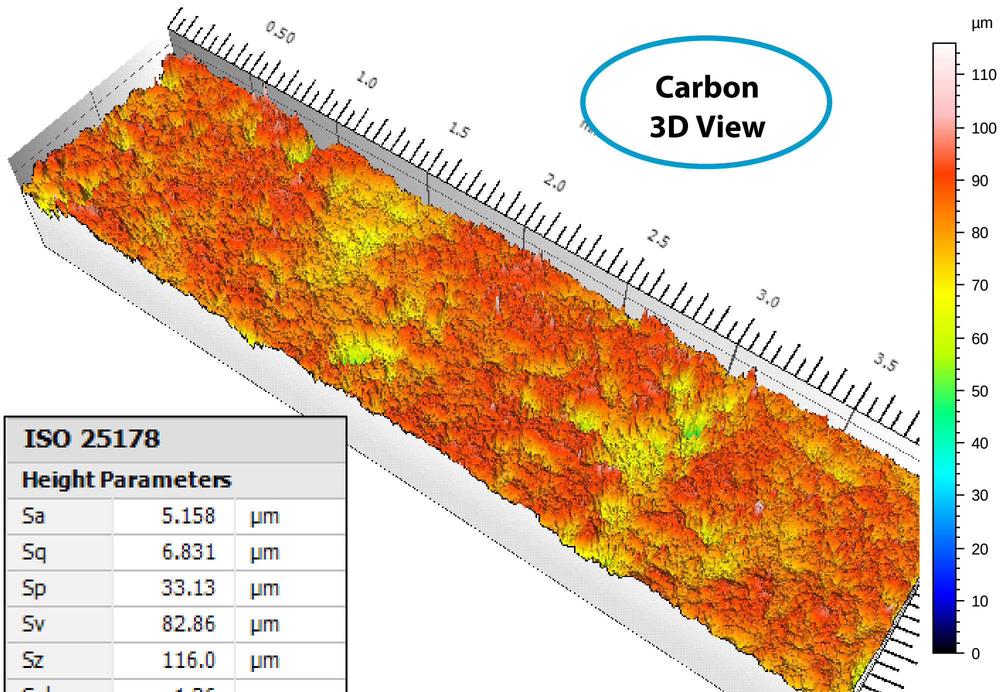
Unlike other techniques such as touch probes or interferometry, the 3D Non Contact Profilometer, using axial chromatism, can measure nearly any surface, sample sizes can vary widely due to open staging and there is no sample preparation needed. Nano through macro range is obtained during surface profile measurement with zero influence from sample reflectivity or absorption, has advanced ability to measure high surface angles and there is no software manipulation of results. Easily measure any material: transparent, opaque, specular, diffusive, polished, rough etc. The technique of the Non Contact Profilometer provides an ideal, broad and user friendly capability to maximize surface studies when pitting analysis will be needed; along with the benefits of combined 2D & 3D capability.

**MEASUREMENT OBJECTIVE**

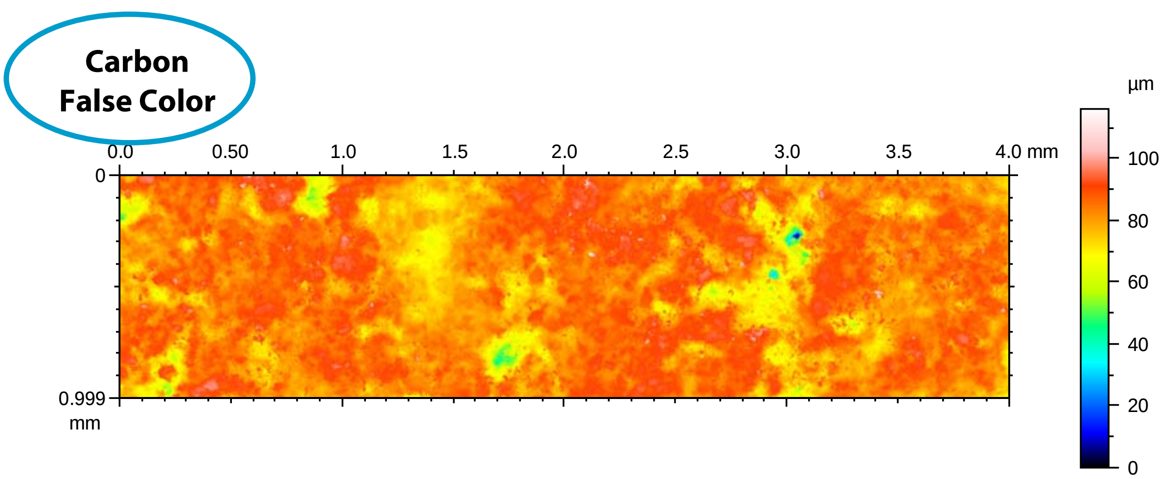
In this application the Nanovea ST400 Profilometer is used to measure the surface of carbon and zeolite catalysts. The area measured was selected at random, and assumed large enough in that it could be extrapolated to make assumptions about a much larger surface. Surface roughness and developed area will be used to characterize the available surface area.

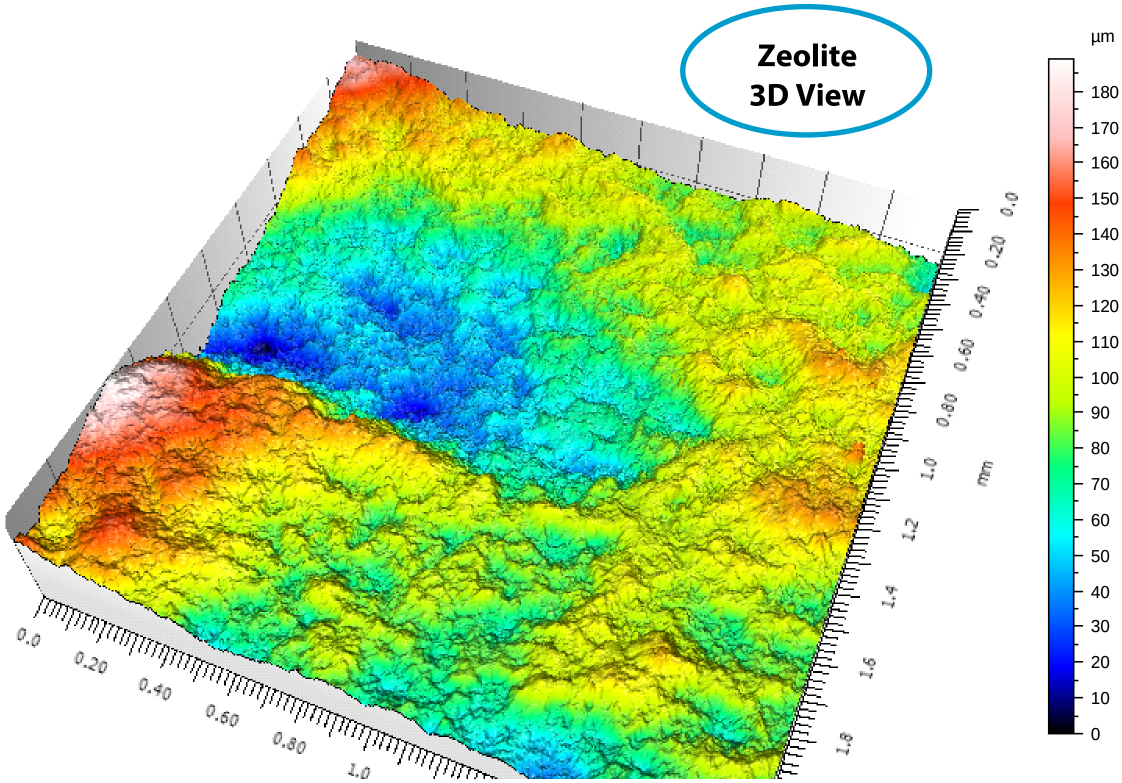
## RESULTS: 3D Surface

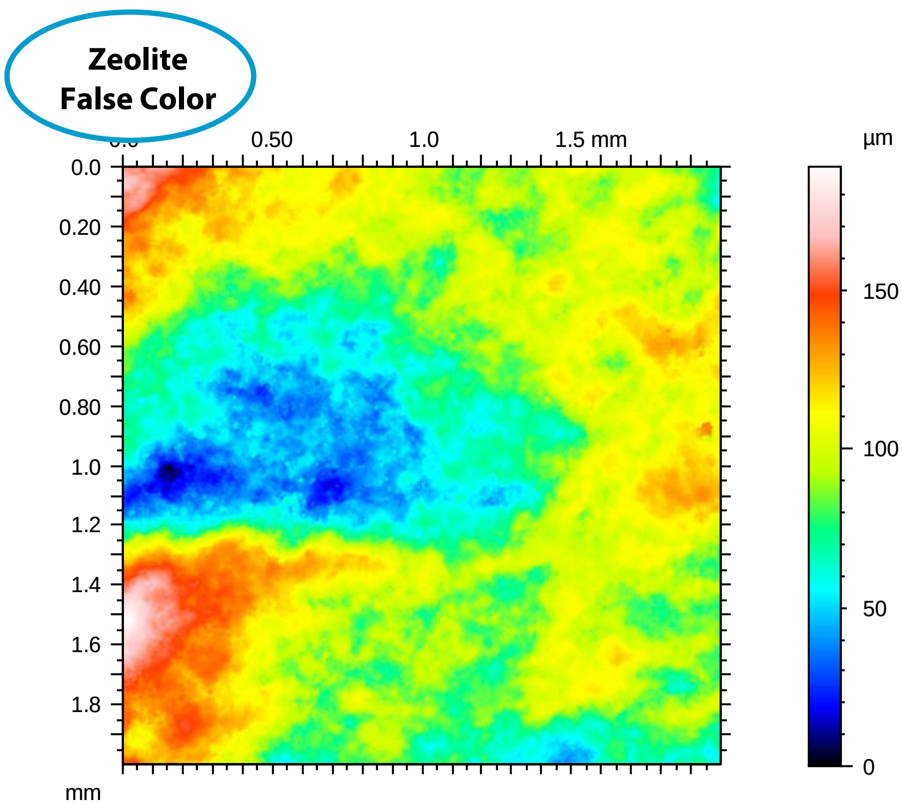
The 3D View and False Color View of a randomly selected area on a carbon and zeolite pellet. It provides users a straightforward tool to directly observe the morphology of the porous surface from different angles. It can be seen from data tables that although the zeolite has a much higher average surface roughness of 21.5μm, the carbon sample has a higher developed surface area of 6.44mm$^2$.




| ISO 25178 | | |
|---|---|---|
| **Height Parameters** | | |
| Sa | 5.158 | μm |
| Sq | 6.831 | μm |
| Sp | 33.13 | μm |
| Sv | 82.86 | μm |
| Sz | 116.0 | μm |
| Ssk | -1.26 | |
| Sku | 7.891 | |
| **Other 3D Parameters** | | |
| **Miscellaneous** | | |
| Spar | 3.999 | mm² |
| Sdar | 6.444 | mm² |






| ISO 25178 | | |
|---|---|---|
| **Height Parameters** | | |
| Sa | 21.50 | µm |
| Sq | 27.67 | µm |
| Sp | 99.34 | µm |
| Sv | 89.73 | µm |
| Sz | 189.1 | µm |
| Ssk | 0.03892 | |
| Sku | 3.148 | |
| **Other 3D Parameters** | | |
| **Miscellaneous** | | |
| Spar | 3.997 | mm² |
| Sdar | 5.651 | mm² |

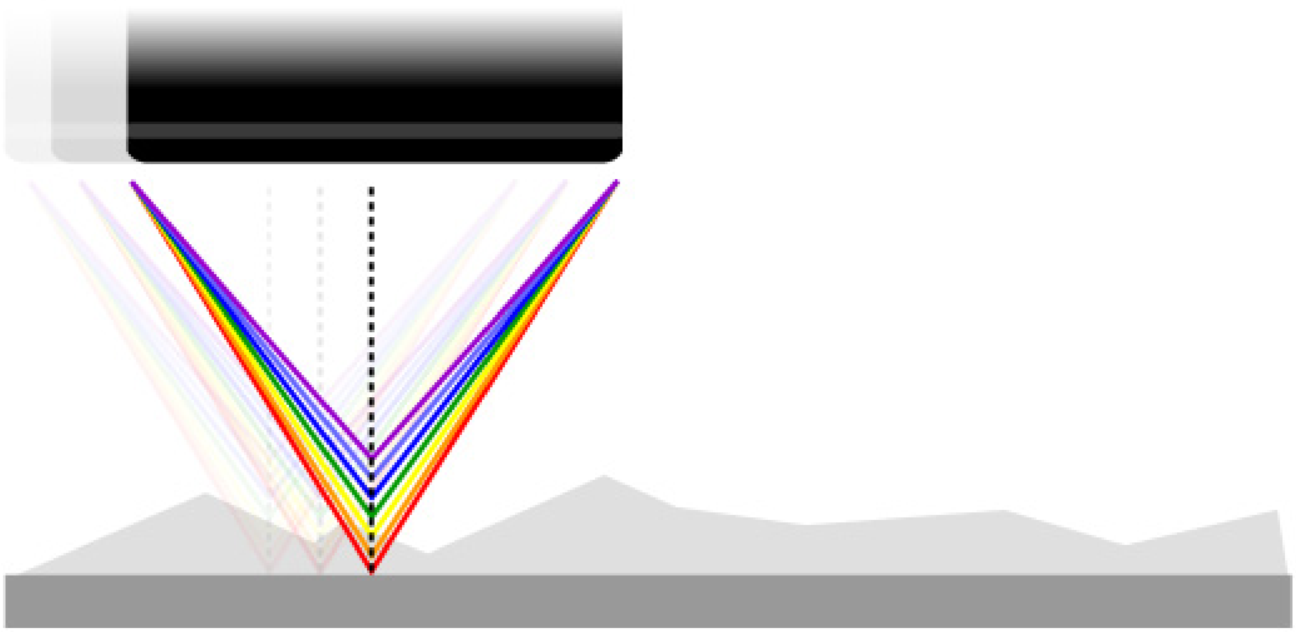
## CONCLUSION:

In this application, we have shown how the Nanovea 3D Non Contact Profilometer can precisely characterize the porous surfaces of carbon and zeolite catalyst pellets. The data shows an average surface roughness of 5.158µm and 21.50µm for the carbon and zeolite respectively. The developed surface area was found to be 6.444mm$^2$ for the carbon and 5.651mm$^2$ for the zeolite. That's an increase over the projected surface area of 61.1% for the carbon and 41.4% for the zeolite. The data shown here represents only a portion of the calculations available in the analysis software.

Learn more about the Nanovea Profilometer or Lab Services

## MEASUREMENT PRINCIPLE:

The Chromatic Confocal technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white light will re-focus at a different distance from the lens (different height). When the measured sample is within the range of possible heights, a single monochromatic point will be focalized to form the image. Due to the confocal configuration of the system, only the focused wavelength will pass through the spatial filter with high efficiency, thus causing all other wavelengths to be out of focus. The spectral analysis is done using a diffraction grating. This technique deviates each wavelength at a different position, intercepting a line of CCD, which in turn indicates the position of the maximum intensity and allows direct correspondence to the Z height position.



Unlike the errors caused by probe contact or the manipulative Interferometry technique, Chromatic Confocal technology measures height directly from the detection of the wavelength that hits the surface of the sample in focus. It is a direct measurement with no mathematical software manipulation. This provides unmatched accuracy on the surface measured because a data point is either measured accurately without software interpretation or not at all. The software completes the unmeasured point but the user is fully aware of it and can have confidence that there are no hidden artifacts created by software guessing.

Nanovea optical pens have zero influence from sample reflectivity or absorption. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent or opaque, specular or diffusive, polished or rough. Measurement includes: Profile Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height Depth Thickness and many others.

## DEFINITION OF HEIGHT PARAMETERS

| Height Parameter | | Definition |
|---|---|---|
| Sa | Arithmetical Mean Height | Mean surface roughness. $Sa = \frac{1}{A}\iint_A \lvert z(x,y)\rvert dxdy$ |
| Sq | Root Mean Square Height | Standard deviation of the height distribution, or RMS surface roughness. $Sq = \sqrt{\frac{1}{A}\iint_A z^2(x,y)dxdy}$ Computes the standard deviation for the amplitudes of the surface (RMS). |
| Sp | Maximum Peak Height | Height between the highest peak and the mean plane. |
| Sv | Maximum Pit Height | Depth between the mean plane and the deepest valley. |
| Sz | Maximum Height | Height between the highest peak and the deepest valley. |
| Ssk | Skewness | Skewness of the height distribution. $Ssk = \frac{1}{Sq^3}\left[\frac{1}{A}\iint_A z^3(x,y)dxdy\right]$ Skewness qualifies the symmetry of the height distribution. A negative Ssk indicates that the surface is composed of mainly one plateau and deep and fine valleys. In this case, the distribution is sloping to the top. A positive Ssk indicates a surface with a lot of peaks on a plane. Therefore, the distribution is sloping to the bottom. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement. |
| Sku | Kurtosis | Kurtosis of the height distribution. $Sku = \frac{1}{Sq^4}\left[\frac{1}{A}\iint_A z^4(x,y)dxdy\right]$ Kurtosis qualifies the flatness of the height distribution. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement. |
| Spar | Projected Area | Projected surface area. |
| Sdar | Developed Area | Developed surface area. |