

# Raman spectroscopy analyses of road construction materials

Various solid materials used in road construction were analyzed using a handheld Raman spectrometer. The investigated materials are commonly used pigments and resins such as  $\text{CaCO}_3$ ,  $\text{TiO}_2$ , and DEGALAN®. The measured

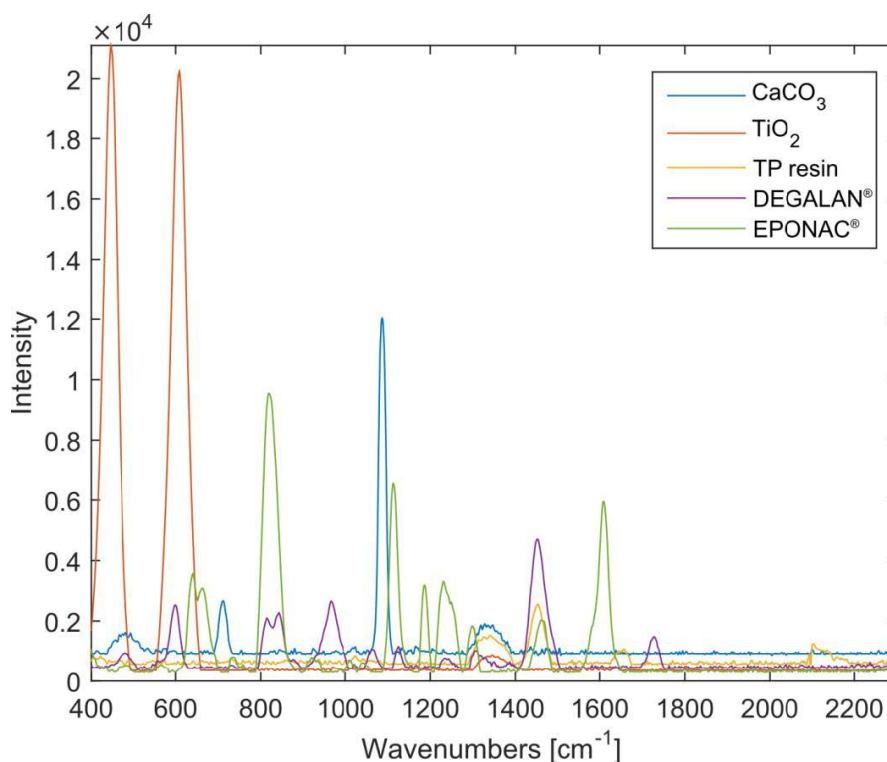
spectra differed remarkably from each other. To evaluate the main differences in the chemical structures, the peaks of the different spectra were assigned to the functional groups causing them.

## INTRODUCTION

Different materials such as paints, (white) pigments, and resins are commonly used in the construction of roads. Together with glass beads (used for night-visible road marking) and various other materials, they help us to get safely from A to B.

In this study, different roadmaking materials

were analyzed using the Mira M-1 handheld Raman analyzer. The gathered spectra were compared with each other to see the main differences in the functional groups. The analysis proved that Mira M-1 is suited for the differentiation of such materials.



**Figure 1.** Overlay of spectra of different roadmaking materials

## EXPERIMENTAL

All spectra were measured using the Mira M-1 Raman spectrometer in auto-acquisition mode, i.e., integration times were determined automatically. A laser wavelength of 785 nm and the Orbital-Raster-Scan (ORS) technique were applied. The measurements were done in small sample vials with the vial holder adapter. The following samples were investigated:

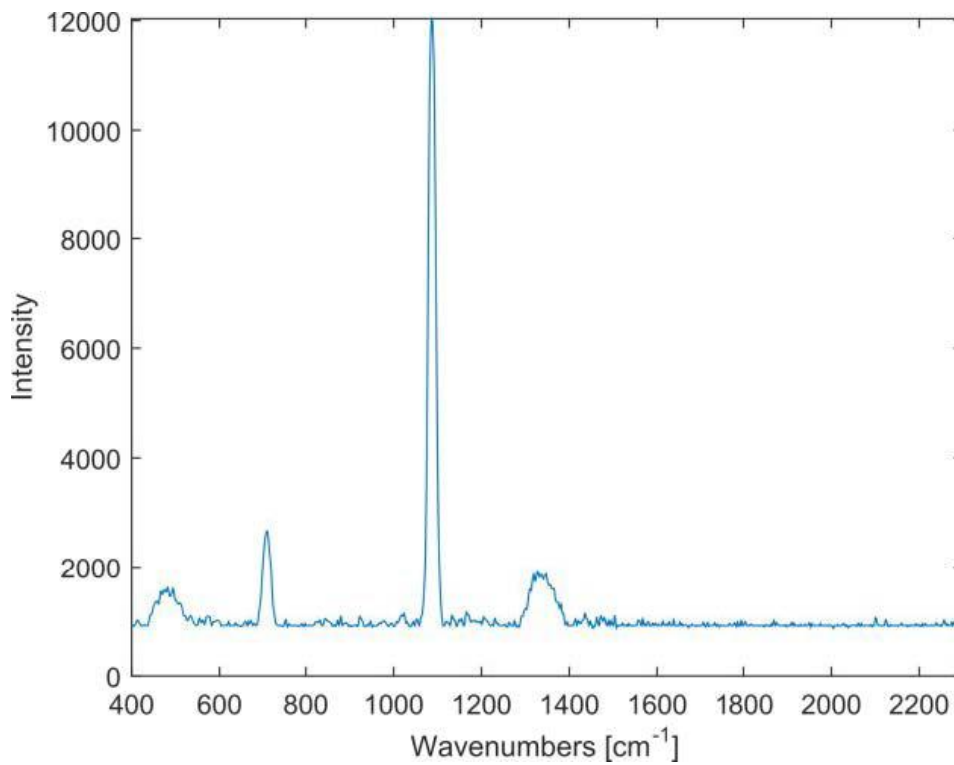
1. Chalk ( $\text{CaCO}_3$ )

2. Titanium dioxide ( $\text{TiO}_2$ )
3. EPONAC<sup>®</sup> resin
4. TP resin
5. Pigment yellow
6. Pigment blue
7. Pigment red
8. DEGALAN<sup>®</sup> resin

## RESULTS AND DISCUSSION

The measurement of calcium carbonate furnished a clear spectrum with two main peaks at  $712\text{ cm}^{-1}$  (symmetric O–C–O bending

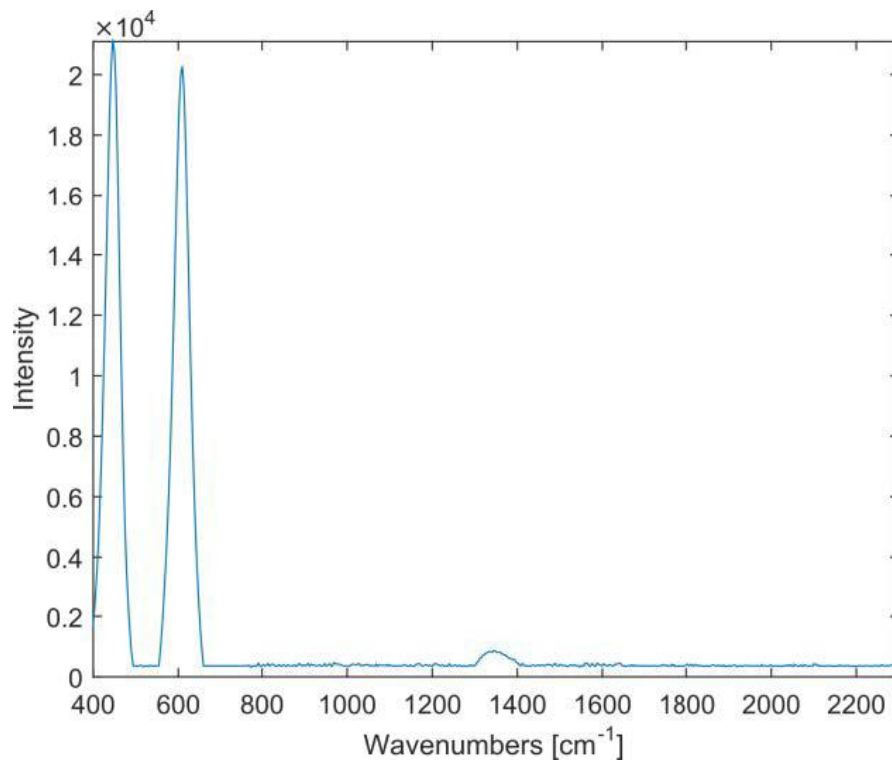
vibration) and  $1087\text{ cm}^{-1}$  (symmetric stretching vibration).



**Figure 2.** Spectrum of calcium carbonate.

Looking at the titanium dioxide spectrum, one can see two main peaks which give information on the present crystal modification (rutile or anatase). Two peaks represent rutile, while three peaks are typical for anatase because of its crystal symmetry.

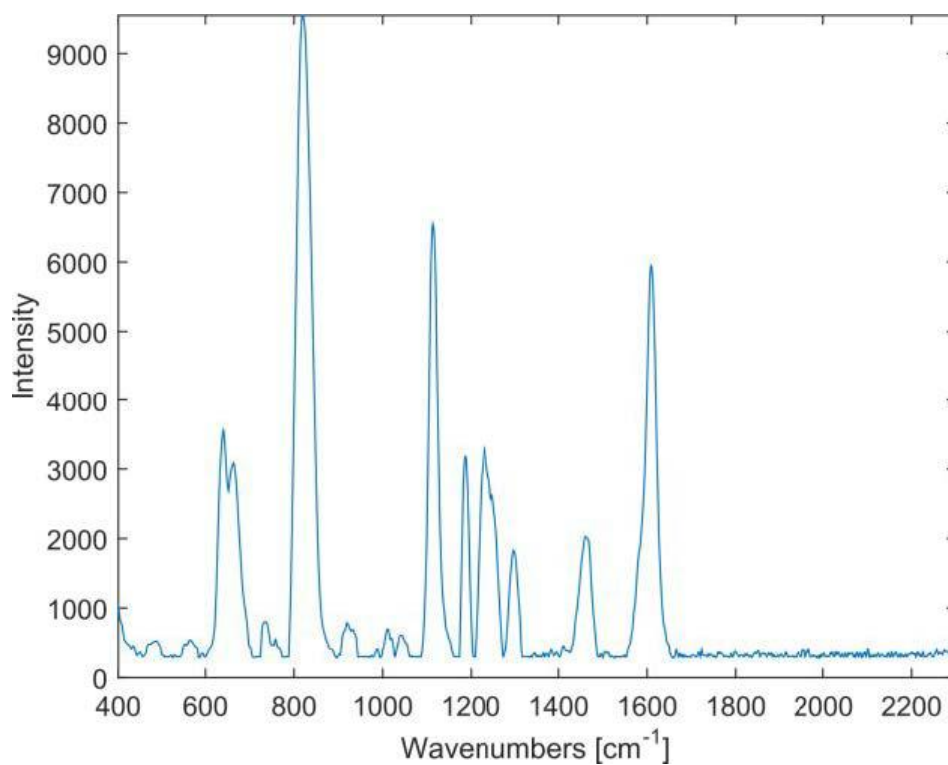
Both peaks are symmetric stretching vibrations and belong to O–Ti–O ( $446\text{ cm}^{-1}$ ) and Ti–O ( $609\text{ cm}^{-1}$ ). In the case of anatase, the peak at  $446\text{ cm}^{-1}$  is split in two. This makes it easy to differentiate between rutile and anatase.



**Figure 3.** Spectrum of TiO<sub>2</sub> (rutile).

A glance at the spectra of typical resins such as EPONAC® or DEGALAN® reveals nicely separated

peaks which can be assigned to their corresponding functional groups (see below).



**Figure 4.** Spectrum of the EPONAC® resin.

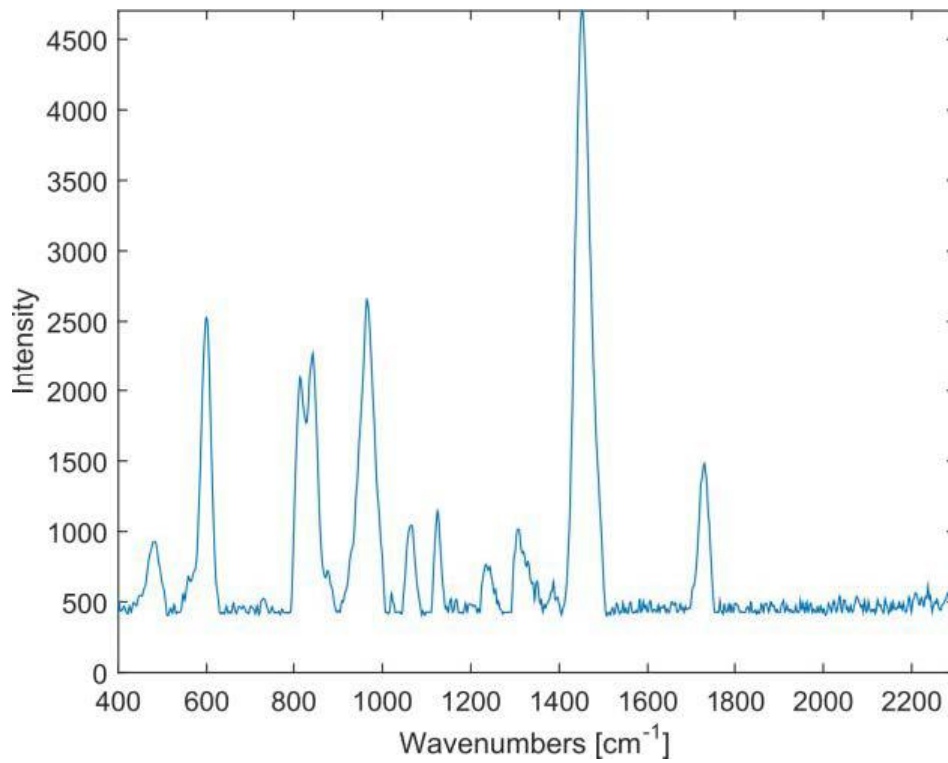
**Table 1.** Peaks observed in the EPONAC® spectrum.

Peak [cm <sup>-1</sup> ]	Description
640	Cyclic vibration (para-substituted benzene)
819	C–H bending vibration (para-substituted benzene)
1000	Various C–C stretching vibrations
1113	C–OH stretching vibration
1189	C–(CH <sub>3</sub> ) <sub>2</sub> stretching vibration
1231	C–O
1248	C–H (benzene)
1298	–CH <sub>2</sub> – twisting vibration
1461	–CH <sub>2</sub> – bending vibration
1609	C=C

The peaks are very characteristic for para-substituted benzene and confirm that EPONAC® is a copolymer of bisphenol A (BPA) and another component.

When comparing the EPONAC® spectrum with the DEGALAN® spectrum (see **Figure 5**), it is

obvious that the peak of the benzene at  $1600\text{ cm}^{-1}$  is missing. The peak around  $1700\text{ cm}^{-1}$ , together with the peaks slightly below and above  $1200\text{ cm}^{-1}$ , is characteristic for carbonyl groups. In addition to that, the C–C peaks are more distinct for EPONAC® than for DEGALAN®.



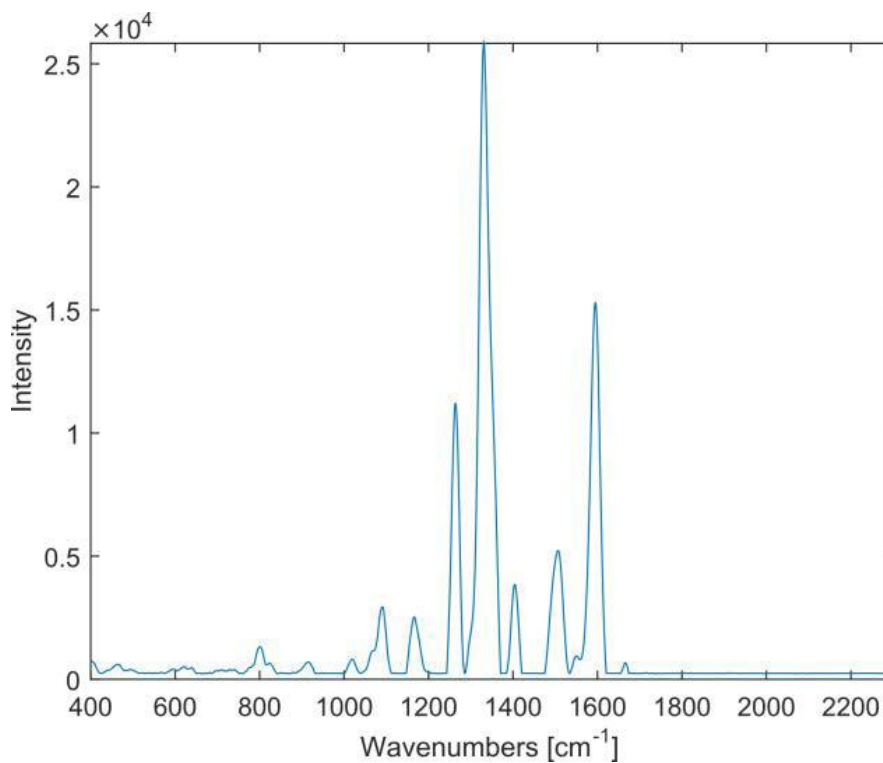
**Figure 5.** Spectrum of the DEGALAN® resin

**Table 2.** Peaks observed in the DEGALAN® spectrum.

Peak [cm <sup>-1</sup> ]	Description
599	-COO bending vibration
814	Propionate bending vibration
843	C-CH <sub>3</sub> stretching vibration
965	C-C stretching vibration
1065	C-COO stretching vibration
1125	C-O
1234	C-O
1308	-CH <sub>2</sub> - twisting vibration
1452	-CH <sub>2</sub> - bending vibration
1728	C=O carbonyl group, ester

Using these differences, it is easy to discriminate between the resins and also between resins and

pigments (see **Figure 6**).



**Figure 6.** Spectrum of the yellow pigment «Hansa®-Brilliantgelb»

## CONCLUSIONS

Because of the great differences in their spectra, handheld Raman spectroscopy is ideally suited for the analysis of materials used in road construction. The investigation of the spectra

showed that there are significant differences in the functional groups of the materials, thus allowing the identification with handheld Raman systems such as Mira M-1.

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## CONFIGURATION



### MIRA P Advanced

瑞士万通快速拉曼分析 (MIRA) P 是一款性能大的手持式拉曼光,可用于各材料的快速无定和,例如物有效成分和形。MIRA P 小而固,具有高效的,配了万通独一无二的逐格描技 (ORS)。MIRA P 符合 FDA 邦法 21 章第 11 款的定

。Advanced Package 包含一个附加透,可用它直接分析材料或者在材料容器中分析(3b 激光器),有一个小管支架套筒用于分析玻璃小管中的本(1 激光器)。