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Novel nanocomposite of $Ca(OH)_2$-incorporated zeolite as an additive to reduce atmospheric emissions of PM and VOCs during asphalt production

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SUPPLEMENTARY DATA

S-1:Analytical process

(S-1); GC/MS has a high sensitivity detection (average: less than 1 ppm) and is used to identify the volatile organic compounds. Analyses were carried out on a Varian 3400 CX gas chromatograph (GC), which was connected to a GC-MSD, CP-3800 mass spectrometer. Ionization mode of mass spectrometer was EI (electron impact) at 70 eV. The mass range scanned was from m/z 35 to 280 amu. The gas chromatograph/ mass spectrometer interface temperature was 200 while the ion source temperature was 195 ^{o}C. The GC injection port was maintained at a temperature of 250 ^{o}C for thermal desorption. Separation was carried out on a 60 m × 0.32 mm × 1 µm DB-1 capillary column (J & W Scientific, USA), while column oven temperature was initially held at 40 ^{o}C for 4 min, programmed to 190 ^{o}C at a rate of 7/min, and then to 250 ^{o}C at 10 ^{o}C /min. The sample was quantified by selected ion monitoring (SIM). Quantification of the ions (m/z) is shown in **Table S-2**. High-purity helium (99.995%) was used as a carrier gas at a flow-rate of 1 mL/min. Outlet split flow and septum purge flow was 10 mL/min and 3 mL/ min, respectively.

S-1a: Calibration curves and detection limit

The calibration for all twelve VOCs was linear with a correlation coefficient of at least 0.999 over the range of 1-30 ppbv. Detection limit values for target VOCs were shown from 10 pptv to 0.93 ppbv. The detection limit was estimated to be greater than 3 on the basis of the S/N ratio. The precision obtained, expressed as relative standard deviation, was lower than 10%. Three replicate analysis for calibration of target VOCs standard gas was done in this study. Detailed results for all twelve VOCs were summarized in **Table S-2**.

Table S-2; Linearity for target compounds by GC/MS analysis.

Compounds	RT(min)	Q ions	RSD (%) (n=3)	LOD[a] (ppbv)	r^2
1,1-Dichloroethane	5.86	96	5	0.14	0.9997
chloroform	8.26	83	6	0.01	0.9994
1,1,1-trichloroethane	9.41	97	5	0.15	0.9992
Benzene	9.96	98	9	0.01	0.9983
Carbon teterachloride	10.14	117	14	0.38	0.9994
Trichloroethylene	11.26	130	2	0.04	0.9992
Toluene	13.76	91	6	0.01	0.9995
Tetrachloroethylene	15.41	166	4	0.01	0.9988
Ethlybenzene	17.05	91	7	0.01	0.9997
m,p-Xylene	17.33	91	14	0.02	0.9992
Styrene	17.93	104	3	0.01	0.9982
o-Xylene	18.1	91	14	0.02	0.9996

a; 3 replicate analysis

S-3: Details of HPLC determination for monitoring of aldehydes

The monitoring of aldehydes, especially formaldehyde, acetaldehyde and butyraldehyde, are important for the monitoring of air pollution and acid rain problems. These aldehydes are analyzed by HPLC using 2,4-dinitorophenylhydorazine (DNPH) as the derivatization reagent. The cartridge of silica gel that was impregnated with DNPH (DNPH cartridge) is commonly used for the sampling and concentrating of aldehydes in air. This application brief describes the analysis of formaldehyde and acetaldehyde in the air using DNPH cartridge.

Conditions: ***Column*** 250 mm ˘ 4.6 mm i.d. Inertsil ODS 80A; ***Mobile Phase*** CH_3CN/H_2O = 50/50 ***Temperature*** 40 °C ***Injection vol*** 25 µl ***Diode array detector*** A—365/8 nm, reference off.

Limit of Detection: formaldehyde 0.25 µg/m^3, acetaldehyde 0.35 µg/m^3, butyraldehyde 0.35 µg/m^3 (calculated from 3σ of blank values)
Repeatability of RT over 6 runs < 0.1 %
Repeatability of area over 6 runs < 0.5 %

S-4: Specification of Asphalt (AP5) : AP-5 is solid, black, color asphalt and its spontaneous combustion and flash point temperature are 400 and 344 ^oC, respectively. The viscosity of AP5 at 135 ^oC was 0.371 Pa·s.