Effect of Aging with Pollution on the Complex Refractive Index of Pure Submicron Clay Particles [†]

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Abstract: Modelling the optical and radiative properties of atmospheric particles is governed by one of the key input parameters, i.e., the refractive index of aerosols. Availability of the region-specific refractive index data of aerosols is a major challenge for the atmospheric community. The refractive index of aerosols is a function of their physico-chemical properties. Uncertainty in the computation of the spectral refractive indices of aerosols leads to erroneous assessment of their optical and radiative properties. In the present work, the refractive indices of pure clay (kaolinite, illite) and polluted clay with anthropogenic hematite, AH (0.10 to 1.48%) submicron particles have been computed for the wavelength range of 0.38 to 1.2 μm . Anthropogenic hematite enhanced the overall absorption in the UV and visible range with maximum absorption at lower wavelengths (less than 0.55 μm).

Keywords: complex refractive index; submicron pure clay; kaolinite; illite; polluted clay

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1. Introduction

Fine clay particles are natural aerosols present in the atmosphere. Submicron clay particles interact with anthropogenic species during long-range transport, which alters the optical and radiative behavior of particles. The physico-chemical (morphology and composition) properties of an aerosol govern its absorption and scattering behavior [1–4]. The spectral refractive index is an important parameter in governing the optical properties of aerosols [2,5,6]. The refractive index is composed of real and imaginary parts. The real part of the refractive index is responsible for the scattering behaviour of the aerosol, while its absorbing nature is determined by the imaginary part [7,8].

For the assessment of optical and radiative properties of aerosols, it is necessary to understand the complex refractive index of aerosols. In the present work, the effect on the spectral refractive index of pure clay aged with pollution species has been studied.

2. Methodology

The PM_{2.5} aerosol samples were collected in Delhi at CSIR-NPL (28.70° N, 77.10° E) using an Envirotech sampler (model: APM 550). Elemental analysis revealed occurrence of aluminosilicates (kaolinite (K) and illite (I)), which is evidenced by earlier studies [9,10]. Based on the aforesaid findings, the mixture of (20% K + 80% I) of pure clay is considered for the study. Pure clay mixture was then aged with pollution with varying anthropogenic hematite (AH) (0.10% to 1.48%). Effective refractive index was calculated using the volume mixing rule.

3. Result and Discussion

Studies show that the anthropogenic iron emitted from various sources ranges from 0.10% to 1.48%. Figure 1 shows the spectral refractive index of pure submicron clay mixture aged with AH for aforementioned AH percentages, i.e., 0.10% and 1.48%. Aging with AH

increased the overall k value of the refractive index in UV, visible and NIR wavelengths. The maximum enhancement was observed at 0.38 μm wavelength. Hematite acts as strong absorber of incoming solar radiation, especially at short wavelengths in the blue spectral region [1,11–13]. Maximum enhancement in the k value was observed below the wavelength of 0.55 μm .

Figure 1. Imaginary part of the refractive index, k of submicron clay particles (20% Kaolinite + 80% Illite mixture) which are polluted with varying percentage of anthropogenic hematite 0.10% and 1.48%. Where K = Kaolinite; I = Illite; AH = Anthropogenic Hematite.

4. Conclusions

The complex refractive index of pure submicron clay particles is influenced by the aging with the considered species. Anthropogenic species such as AH enhance the absorption due to their absorbing behaviour.

Conflicts of Interest: The authors declare no conflict of interest.

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