Separation and Nondestructive Identification of Solid Particles by NeFeB Permanent Magnets with Microgravity: Towaed "Solid-State Version Chromatography"

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Chromatography is a well-known method for separating gas or liquid components from mixtures but is unavailable for mixtures of solids. Here, we describe a practical analytical method for separating mixed solid particles that can be thought of as a kind of "solid-state version of chromatography". In this method, solid particles are released into a magnetic field gradient under a microgravity field, and the particles undergo translational motion due to the magnetic field gradient force. As the velocity of the particles does not depend on the individual mass of the particles but rather on the intrinsic magnetic susceptibility of the material, we hypothesize that mixtures of diamagnetic solid particles can be separated into each material type. We built an apparatus equipped with neodymium magnets and a high-speed camera. A combined magnetic field and microgravity environment can be produced by allowing the apparatus to free fall a distance of 1.8 m. Then, solid particles (Bi, C, Al2O3, CaCO3, Ag) are separated and evaluated in the apparatus. We were able to separate solid particles and identify each type of particle based on differences in magnetic susceptibility. Previously, magnetic separation of solid materials was limited to ferromagnetic or paramagnetic material. However, based on the capability to magnetically separate diamagnetic materials, which account for the majority of materials, we developed a method that can be extended to all solids. This analytical separation method may have practical applications as a pretreatment for the separation of heterogeneous samples of mixed particles.

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