Pulmonary Deposition and Clearance of a Nickel Oxide Aerosol by Inhalation

YASUSHI KODAMA,1,* SHIGEKO ISHIMATSU,1 KOJI MATSUNO,1 ISAMU TANAKA,2 AND KENZABURO TSUCHIYA3

1*Department of Environmental Health, School of Medicine, University of Occupational and Environmental Health, Japan 1-1, Iseigaoka, Yahata Nishi-ku, Kitakyushu, 807 Japan; 2Department of Environmental Health Engineering, School of Medicine, University of Occupational Health, Japan 1-1, Iseigaoka, Yahata Nishi-ku, Kitakyushu, 807 Japan; 3President, University of Occupational and Environmental Health, Japan 1-1, Iseigaoka, Yahata Nishi-ku, Kitakyushu, 807 Japan

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ABSTRACT

Wistar male rats were exposed to nickel oxide (NiO) aerosols (mass median aerodynamic diameter, 1.2 μm). The average exposure concentration was controlled from low level (0.6 mg/m³) to high level (8.0 mg/m³) and total exposure time ranged from 140 to 216 h. Some rats were sacrificed just after the exposure, whereas others were exposed for 1 mo and kept for a 1-yr clearance period before sacrifice. There were no differences in body weight gain between NiO exposure groups and controls.

Nickel concentrations in lungs of exposure groups were much higher than those of controls. No apparent deposition of nickel was observed in liver, kidney, spleen, heart, brain, and blood, but lung burdens of up to about 2.35 mg of NiO were found. The apparent deposition fractions were 19.8 and 14.5% after the exposure to average concentrations of 1.4 and 6.5–7.0 mg/m³, respectively.

The clearance rate of NiO deposited in lungs may be small.

*Author to whom all correspondence and reprint requests should be addressed.
INDEX ENTRIES: Nickel oxide, pulmonary deposition and clearance of; inhalation toxicity, of NiO; health effect, of NiO; respirable dust, and NiO toxicology; pulmonary toxicology, of NiO.

INTRODUCTION

The threshold limit values by ACGIH for nickel metal, soluble compounds, nickel sulfide roasting fume and dust, and nickel carbonyl are 1, 0.1, 1, and 0.35 mg/m³, respectively (1). NIOSH recommends a permissible exposure level for nickel of 0.015 mg/m³ (2) and, in accord with the IARC (3), considers that nickel should be regarded as an occupational carcinogen.

The increased incidence of cancer of the respiratory tract among certain groups of nickel workers has been recognized since the report of Bridge (4). Similar reports have been reported in various countries (5,6).

The identity of the nickel compounds that may induce cancers in nickel refinery is uncertain, although principal attention has been focused on insoluble dusts of nickel subsulfide and nickel oxide (NiO), and nickel carbonyl vapor.

Health effects of nickel metal and nickel compounds have been reviewed (7,8). However, there are very few reports on the inhalation toxicity of nickel metal and nickel compounds. Considering this fact and the main exposure route of the workers in occupational environment, inhalation studies are obviously important.

The effects of inhalation of nickel metal dust on rabbit lungs have been investigated at the Karolinska Institute, Sweden (9-12). Bingham et al. (13) reported that the number of alveolar macrophages increased significantly on exposure to nickel oxide. The health effects of nickel enriched fly ash and ordinary fly ash have been investigated, but no difference was found between them (14).

This report describes the results of experimental studies in which rats were exposed to NiO aerosol by inhalation. The exposure conditions and aerosol properties were monitored to provide both physical and chemical data. The burden of NiO was measured by chemical analysis and then used to determine the effective deposition fractions.

METHODS

Test Substances

Respirable aerosols of NiO were generated and transported to exposure chambers. For this study, NiO dust (Soekawa Chem. Ind., Japan) was ground in a ball mill to reduce the particle-size and then fed into a dust generator.