Pilot study for the assessment of health effects of the chemical composition of ultrafine and fine particles in Italy

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ABSTRACT

Endocrine disruptors have been described as "exogenous chemical substances or mixtures that alter the structure or function(s) of the endocrine system and cause adverse effects at the level of the organism, its progeny, populations, or subpopulations" (EPA, 1998).
Several experimental studies reported that also very low doses of endocrine disruptors can affect the endocrine system causing diseases and altering the development of mammalian (humans included) and non-mammalian species. Among the diseases associated with the exposure to endocrine disruptors cancer, cardiovascular risk, modulation of adrenal, gonad and thyroid functions, and endometriosis are those that mainly catch the public concern considering their social cost.
This paper describes the research activity planned in the pilot project on Endocrine Disruptors granted by CNR in the general contest of the Environment and Health Inter-departmental Project (PIAS).

1. Background

A number of epidemiological studies have shown a correlation between fine particle concentration and increased mortality or morbidity. At the same time, due to the complex chemical composition and varying size-distributions of PM_{10} and $PM_{2.5}$, a clear explanation of the mechanisms underlying the toxic effects of atmospheric particulate matter is still elusive (1).
Inhalation of particulate matter leads to pulmonary inflammation and reduction in lung function (2) with secondary systemic effects or, after translocation from the lung into the circulation, to direct toxic effects on cardiovascular function (3) and on the coagulation pathway thus contributing to the onset of coronary events (4). Through the induction of cellular oxidative stress and proinflammatory pathways (4), particulate matter augments the development and progression of atherosclerosis (5). The main factor of these adverse health effects seems to be combustion-derived nanoparticles that incorporate reactive organic and transition metal components. An important source of these particles is new diesel cars with oxidizing converters, such as modern taxis in North Europe.
Many epidemiological, human clinical, and animal studies showed that ultrafine particles (UFPs) penetrate deeply into the lungs initiating an inflammatory response leading to respiratory diseases and may be absorbed directly into the circulating blood, causing cardiovascular diseases (6). Recent studies highlighted the importance of identifying susceptible sub-populations and mechanisms of involved effects. Several chronic clinical conditions are good candidates to define the population susceptible to UFP acute effects, while elevated levels of oxidatively altered biomolecules are important intermediate endpoints that may be useful markers in

hazard characterization of particulates (7). At present, UFPs are not usually monitored by air quality stations. Thus, current epidemiological studies have to rely on PM10 data.

Previous studies have pointed to chemical species occurring in trace amounts, having known carcinogenic and mutagenic effects like PAHs (8,9,10) or "heavy" metals (11). Others have focused on the peculiar properties of ultrafine particles (with a diameter below 0.1 μm) to penetrate biological membranes (12). Overall, despite the increasing amount of data provided by both laboratory and field studies, the nature of the aerosol particles fraction inducing health effects is still a matter of debate. This issue is important, because the different aerosol constituents exhibit distinct sources and emission/ formation processes (13,14). Therefore, linking toxicological and epidemiological impacts of atmospheric particulate matter to their chemical composition is a key to evaluate effective pollution abatement strategies (15,16).

The existing networks of stations monitoring particulate matter concentration, usually PM_{10} or $PM_{2.5}$ mass, are not designed to provide chemical composition and size-distribution data. In Italy, only at the two EMEP stations of Ispra (VA) and Montelibretti (RM), the chemical composition of PM_{10} and $PM_{2.5}$ is routinely measured. At the same time, an increasing series of data on the aerosol chemical composition and size-distribution have been provided by short-term intensive field studies performed in the frame of national and European research projects (17). During these experiments, state-of-the-art instrumentation has been deployed for aerosol characterization. For instance, multi-stage impactors were used to provide size-resolved chemical composition data, down to the ultrafine or quasi-ultrafine size range. At the same time, the chemical analysis of fine particulate samples has shown that even in urban areas the water-soluble fraction of the aerosol contains large amounts of poorly characterized organic compounds (WSOC, "water-soluble organic carbon"), in contrast to the paradigm of many toxicological studies which attributes the organic-soluble and water-soluble fractions of the aerosol to organic and inorganic compounds, respectively. On the contrary, recent findings point to WSOC as a major agent for aerosol toxicity and oxidizing properties (18,19). In summary, by examining the priorities for the evaluation of upcoming research activities of the Italian National Research Council (CNR) to link atmospheric aerosols composition and properties to their health effects, at least two specific key issues can already be addressed and dedicated to a) ultrafine particles and b) WSOC.

This pilot study will combine the results of two advanced activities in the field of atmospheric ultrafine particles composition and their toxicological properties, carried out by CNR-ISAC (CNR Institute of Atmospheric Sciences and Climate) and CNR-IIA (CNR Institute of Atmospheric Pollution Research) (WP1, WP2) with two new advanced health studies carried out by CNR-IFC (CNR Institute of Clinical Physiology) and CNR-IBIM (CNR Institute of Biomedicine and Molecular Immunology) (WP3, WP4) aimed at exploring short-term effects due to air pollutants exposure in subjects with pre-existent arrhythmia and lung diseases.

The results of the specific advanced environmental and health activities will be evaluated and integrated in WP5 with the final aim of designing an integrated Italian

research activity for future projects to be presented in the frameworks of regional and national projects funded by European Union Structural Funds (PON, POR) or EU Research Funds (EC-FP7).

2. Objectives

1. To collect and compile the available chemical composition data of fine and ultrafine particles in urban and rural sites in Italy;
2. To test the oxidative potential of organic compounds in the water-soluble fraction of submicron aerosol;
3. To evaluate the feasibility of performing epidemiological studies assessing short-term effects of exposure to air pollutants in subjects with pre-existent arrhythmia in Italy;
4. To evaluate the feasibility of epidemiological studies assessing short-term effects of exposure to air pollutants in subjects with pre-existent lung diseases in Italy;
5. To provide the background knowledge to design an integrated research project aimed at assessing the effects of fine and ultrafine particles on human health (to be presented within the framework of PON, POR and EU-FP7).

Work-Packages:

WP1 Assessment of the chemical composition of ultrafine particles and its variability in urban and rural sites in Italy based on available multi-stage impactor data and initial measurements using Aerosol Mass Spectrometers (AMS). (CNR-ISAC, IIA)

WP2 Evaluation of methodologies to measure the oxidative potential of the water-soluble organic fraction (WSOC) of the aerosol. (CNR-ISAC, CNR-IIA)

WP3 A pilot study to assess short-term effects of exposure to air pollutants in subjects with pre-existent arrhythmia. (CNR-IFC)

WP4 A pilot study to assess short-term effects of exposure to air pollutants in subjects with pre-existent lung diseases in Italy. (CNR-IBIM)

WP5 Critical evaluation of the current proposal results and design of a common experimental strategy for an integrated future project on the health effects of fine and ultrafine particles (CNR-ISAC, CNR-IIA, CNR-IBIM, CNR-IFC).

With the contribution of PS2 participants: F. Bianchi (CNR-IFC), S. Decesari (CNR-ISAC), G. Viegi (CNR-IBIM), R. Sicari (CNR-IFC).

Keywords: Ultrafine particles (UFPs), water-soluble organic carbon (WSOC), cardiopulmonary diseases.

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