Dinitrosopiperazine (DNPZ) and N-nitrosopiperazine (NPZ): Toxicological properties and acceptable exposure levels for the general population

Camille Bossard1, Lisa Bertomeu1, Pierre-Gérard Pontal1 and Nathalie Ledirac1

CEHTRA, Consultancy for Environmental and Human Toxicology and Risk Assessment
1CEHTRA Bordeaux, 43-45 Rue Laroque, 33650 Sainte-Eulalie, France
2CEHTRA Paris, 25 Rue des Bas, 92600 Asnières-sur-Seine, France
www.cehra.com

Introduction

CO₂ is an environmental concern gas, contributing to climate change. CO₂ capture by amines and storage is one of the promising technologies to reduce greenhouse gas emissions. To be used, this method needs economic but also environmental acceptance (Pires et al., 2011). Nevertheless, amines used in CO₂ capture process react with flue gas components to form degradation products and some of these compounds may have potential adverse effect on human health and environment.

The aim of the DALMATIEN project (supported by the French National Research Agency), was to study the degradation of two amines used in post-combustion CO₂ capture (monoethanolamine and piperazine). Among the compounds released from a carbon capture plant, several nitrarnes were identified, including N,N'-dinitrosopiperazine (DNPZ) and N-nitrosopiperazine (NPZ).

Results and Discussion

Very few data were available on N-nitrosopiperazine (NPZ) and Dinitrosopiperazine (DNPZ) toxicity (Table 1). DNPZ was shown to be mutagenic and clastogenic in different in vitro and in vivo studies whereas NPZ was not mutagenic. Both nitrosamines induce tumors and more particularly tumors of the nasal cavity in different strains of rats and mice. Concerning reproductive toxicity, fetotoxic effects were observed at maternal toxic dose levels in mice exposed to DNPZ (100 mg/L) during the last week of gestation. For NPZ, no reproductive data were identified; however, both TOPKAT and DEREK consider that it has a potential reprotoxic effect (Table 2).

Data coming from the carcinogenicity studies were used as starting points to extrapolate Acceptable Exposure Levels (AELs) for the general population. Route to route extrapolation and assessment factors were applied according to ECHA guidance chapter R.8 (ECHA, 2010 - Table 3). As most of these data came from studies that were performed with only one or two different doses tested on a limited number of animals, very high safety factors had to be applied.

Conclusions

Based on the available information, AELs for the general population of 1 ng/m³ and 14 ng/m³ for DNPZ and NPZ were proposed, respectively, for the general population.

These values are within the range of concentrations of other nitrosamines that were determined to provide cancer risk of determined to provide cancer risk of 10⁻¹⁰ (1 in 1,000,000) by the US EPA. 2 ng/m³ for N-Nitrosopyrrolidine and 0.6 ng/m³ for N-Nitroso-di-n-butylamine (US EPA, 2011a and b).

Materials and Methods

Table 1. Summary of literature data

Conservative AELs of 1 ng/m³ and 14 ng/m³ for DNPZ and NPZ were proposed, respectively, for the general population. These determinations were aimed to provide cancer risk of determined to provide cancer risks of 10⁻¹⁰ (1 in 1,000,000) by the US EPA. 2 ng/m³ for N-Nitrosopyrrolidine and 0.6 ng/m³ for N-Nitroso-di-n-butylamine (US EPA, 2011a and b).

Table 2. QSAR analyses of P2, NP2 and DNP2

Table 3. General Population Inhalation Acceptable Exposure Limit (AEL) derivation.

References

Birnbaum LS et al. (1988), Cancer Res. 48: 3425
ECHA (2010). Guidance on information requirements and chemical safety assessment – Chapter III
Love LA and Lijinsky LK (1977), Chem. & Ind. 1978:669-673
Takano T et al. (1982), Cancer Res. 42:3916-919
Williams M et al. (2011), Bioaccumulation, hydrolysis and photolysis: Assessing the risk of nitrarnines in aquatic systems.