Universiteit Antwerpen

IAEAC

Book of Abstracts

ISEAC-37

37th International Symposium on Environmental Analytical Chemistry

analytikjena

POSTER CONTRIBUTION II-62.

IMPACTS OF VEHICULAR TRAFFIC EMISSIONS ON STONE DECAY OF HISTORICAL MONUMENTS: DEPOSITION OF POLYCYCLIC AROMATIC HYDROCARBONS

K. Slezáková[1,3,*], D. Castro[1,3], A. Begonha[2], C. Delerue–Matos[3], M.C. Alvim–Ferraz[1], S. Morais[3] and M.C. Pereira[1]

[1] Universidade do Porto, Faculdade de Engenharia, Departamento de Engenharia Química, LEPAE
Rua Dr. Roberto Frias s/n, PT-4200-465 Porto, Portugal

[2] Universidade do Porto; Faculdade de Engenharia, Departamento de Engenharia Civil
Rua Dr. Roberto Frias s/n, PT-4200-465 Porto, Portugal

[3] Instituto Superior de Engenharia do Porto, REQUIMTE
Rua Dr. António Bernardino de Almeida 431, PT-4200-072 Porto, Portugal

* slezakok@fe.up.pt

ABSTRACT

Throughout Europe, there is evidence that some buildings may deteriorate due to the actions of air pollutants present in the atmosphere. In that regard, pollutants from traffic emissions are especially important. Thus, the aim of this work was to evaluate the role of traffic-related pollutants in degradation of historical building facades, and in particular to assess the atmospheric depositions and patterns of polycyclic aromatic hydrocarbons (PAHs) in stone decay of a historical monument. The levels of 18 PAHs (16 U.S. EPA priority pollutants, dibenzo[a,l]pyrene and benzo[j]fluoranthene) were determined during 40 days of winter 2008 in air (both in gas phase and in different size fractions of particulate matter, i.e., in PM_{10} and $PM_{2.5}$), and in samples of black crusts and thin black layers collected from facades of the historical monument Lapa Church in Oporto, Portugal. The mean concentration of 18 PAHs in air was 69.9 $ng.m^{-3}$ (16.8 - 149), 652 $ng.g^{-1}$ (85.9 - 1350) in black crusts, and 96 $ng.g^{-1}$ (5.4 - 430) in thin black layers. Diagnostic ratios confirmed that traffic emissions were the major source of PAHs in air and in both deteriorations, with PAH composition profiles being similar for black crusts, thin black layers, and PM_{10} and $PM_{2.5}$. Accumulation of particulate matter and associated PAHs in black crusts and thin black layers contributes to potential damage of monuments, thus showing that traffic pollutants have a relevant impact on stone decay of historical building façades.

Acknowledgement. This work was funded with FCT fellowship SFRH/BPD/65722/2009.

Impacts of vehicular traffic emissions on stone decay of historical monuments: deposition of polycyclic aromatic hydrocarbons

K. Slezakova[1,2], D. Castro[1,2], A. Begonha[3], C. Delerue-Matos[2], M.C. Alvim-Ferraz[1], S. Morais[2], M.C. Pereira[1]

[1]*LEPAE, Departamento de Engenharia Química, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal*
[2]*REQUIMTE, Instituto Superior de Engenharia do Porto, Rua Dr. António Bernardino de Almeida 461, 4200-072 Porto, Portugal*
[3]*Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal*
slezakok@fe.up.pt; dce05008@fe.up.pt; abegonha@fe.up.pt; cmm@isep.ipp.pt; aferraz@fe.up.pt; sbm@isep.ipp.pt; mcsp@fe.up.pt

Objectives

- To evaluate the role of air pollutants in stone decay of a historical monument
- To assess the atmospheric depositions and patterns of polycyclic aromatic hydrocarbons (PAHs) in façades of historical monument

Methods

AIR SAMPLING

- 18 PAHs (16 USEPA PAHs recommend as priority pollutants, dibenzo[a,l]pyrene, benzo[j]fluoranthene)
- Collection of PAHs in gas phase and associated with atmospheric particles (fractions PM_{10} and $PM_{2.5}$)
- Location: urban site with predominant traffic influence in Oporto, Portugal
- Period: 40 days during winter 2008

MONUMENT FAÇADES

- Black crusts and thin black layers collected at various points from façades of historical monument Lapa church

Lapa church, Oporto

ANALYTICAL METHODS

- Microwave assisted extraction for PAHs in particles, polyurethane foam plugs, crusts, and black thin layers
- Liquid chromatography with fluorescence and diode array detectors in series

MORPHOLOGICAL CHARACTERIZATION

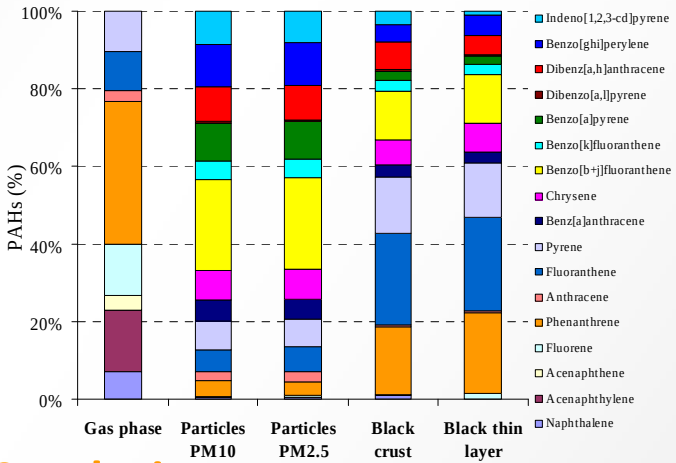
- Scanning electron microscopy (SEM) combined with X-ray microanalysis (EDX)

Example of black thin layer collected from façade of Lapa church

Example of black crust collected from façade of Lapa church

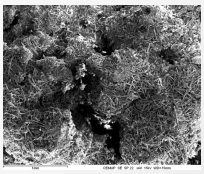
Results

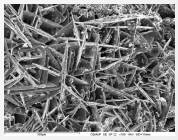
Relative abundance of PAHs in air (gas phase and particles - fraction PM_{10} and $PM_{2.5}$), and in facades of Lapa church (crusts and black thin layers)



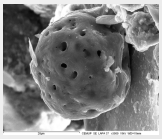
SEM images of particles typically identified in black crusts from façades of Lapa church

General aspect





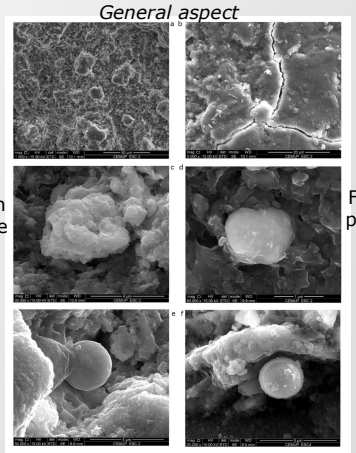
Gypsum ($CaSO_4.2H_2O$)



C-composed porous fly ash

SEM images of thin black layers from façades of Lapa church

General aspect



Pb-rich particle

Fe-rich particle

Fly ash rich in Fe_2O_3

Fly ash rich in SiO_2, Al_2O_3

Conclusions

- The total concentration of 18 PAHs (Σ_{PAHS}) in air ranged between 16.8 and 149 ng/m^3 with a mean of 69.9 ng/m^3. In black crusts the concentration of Σ_{PAHS} ranged from 85.9-1350 ng/g (mean of 652 ng/g) whereas it was 5.4-460 ng/g (mean of 96 ng/g) in black thin layers. The existence of the considerable levels of PAHs deposited in buildings and monuments may lead to higher human exposures thus representing additional risks.
- SEM-EDX analyses revealed that black crusts were predominantly composed of gypsum ($CaSO_4.2H_2O$), with impurities mostly of Si, Al, K, and NA. Particles rich in Fe, Pb, Si and Al were typically found in thin black layers.
- The PAH composition profiles were similar for particles (both PM_{10} and $PM_{2.5}$), black crusts, and thin black layers. Deposition of atmospheric pollutants from traffic emissions, namely of particles (to which PAHs are bound to) thus might represent a significant cause for deterioration of monuments and historical buildings.

Acknowledgments: This work was supported by Fundação para Ciência e Tecnologia with grants PEst-C/EQB/LA0006/2011, PEst-C/EQB/UI0511/2011, and fellowship no. SFRH/BPD/65722/2009.