MOLECULAR CONTAMINATION FROM SPACE MATERIALS: SPECIES CHARACTERIZATION BY TGA/MS

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ABSTRACT

Molecular contamination outgassing and reemission kinetics are of interest for satellite design. Current physical models used for molecular contamination are based on kinetic parameters corresponding to each contaminant species. Different types of molecules are, indeed, more likely to show different outgassing and reemission behaviours. Experiments only provide us access to the global mass gain or loss, either for outgassing or reemission steps. It is equal to the sum of the contributions of each species, but does not give the accurate specific information on one particular species. This leads to large uncertainties on the influence that one species has on the global mass signal. Long term predictions made with those uncertainties may display errors of several orders of magnitude. Determining parameters specific to each species leads to drastic changes on modelling results. It is therefore essential to be able to carry on characterization experiments accurate enough to identify and quantify each type of contaminant, and then calculate their specific parameters. Some methods already exist to get such information, such as gaseous chromatography coupled with mass spectrometry (GC/MS) or Fourier transform infrared spectroscopy (FTIR), but they present the disadvantage of a sample transfer or a time delay between the experiment and the effective characterization. As a consequence, information about outgassing or reemission kinetics is lost. The current work presents an in-situ quantitative and qualitative characterization method for molecular contaminants. Experiments are carried out with the COPHOS facility at ONERA. This method is based on the coupling of thermogravimetric analysis with quartz crystal microbalances (QCM) and mass spectrometry analysis from which outgassing and reemission kinetics are calculated. The recent efforts were focused on two crucial points: the thermal constraints of the equipment were overcome and brand new experimental protocols were developed. To better understand outgassing and reemission phenomena, one can smartly set up the temperature of the effusion cell or the cold surfaces in the direct view of it. A new procedure has been developed to characterize the residual contamination. It consists in carrying out successively twice the usual protocol. The first is executed with no material, while the second is carried out with the material to be characterized. Results showed very high accuracy on residual contamination, making even the smallest signals coming from one species detectable. In addition, the development of a new outgassing procedure, using several effusion cell temperature steps during a short time (three to four hours in total), leads to significantly better results on outgassing kinetics measurements and outgassing modelling. Materials characterized with this technique are space used adhesives, resins and multilayer insulators, on a temperature range representative of a satellite flight. Results coming from this method on such materials are shown in the current work. They have a direct impact on outgassing and reemission properties of contaminants, in-flight molecular contamination predictions and satellite design.