



71st Conference of the Italian Thermal Machines Engineering Association, ATI2016, 14-16
September 2016, Turin, Italy

Natural gas trace compounds analysis with innovative systems: PTR-ToF-MS and FASTGC

Davide Papurello^{a,b*}, Silvia Silvestri^b, Luca Tomasi^b, Ilaria Belcari^b, Franco Biasioli^b,
Massimo Santarelli^a

^aEnergy Department, Politecnico di Torino, C.so Duca degli Abruzzi 24, 10129, Torino - ITALY

^bFondazione Edmund Mach, Via E. MACH 1, San Michele all'adige (TN), 38010 - ITALY

Abstract

The technique of proton transfer reaction mass spectrometry (PTR-MS) couples a proton transfer reagent, usually H₃O⁺, with a drift tube and mass spectrometer to determine concentrations of volatile organic compounds. Proton transfer reaction-mass spectrometry (PTR-MS) has successfully been applied to a wide variety of matrices to identify and to investigate on the behavior of trace compounds; among the possible field of applications we can find: food, air, energy, etc. Natural gas is considered as a fuel for high energy efficiencies applications such as SOFC generators. The ability to distinguish several isobaric aldehydes, ketones, isoprenoids and other compounds is impossible using PTR-MS instrument. In the present research work, PTR-ToF-MS was coupled to a prototype FastGC system allowing for a rapid (90 s) chromatographic separation of the sample headspace prior to PTR-MS analysis. The system was tested on natural gas trace compounds to individuate the major elements and to identify possible issues for the SOFC generators. In comparison to the results obtained by direct injection, FastGC provided additional information, thanks to a less drastic dilution of the sample and due to the chromatographic separation of isomers. This was achieved without increasing duration and complexity of the analysis.

© 2016 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the Scientific Committee of ATI 2016.

Keywords: PTR-MS, FAST-GC, SOFC, trace compounds, biogas.

* Corresponding author. Tel.: +39-3402351692. E-mail address: davide.papurello@polito.it

Nomenclature

PTR-ToF-MS, Proton Transfer Reaction Time of Flight Mass Spectrometer,
FastGC, Fast Gas Chromatography,
SOFC, Solid Oxide Fuel Cell,

1. Introduction

Nowadays, high efficiency and high reliability of the energy generators systems must be achieved to penetrate the energy market. SOFC systems couple the high and stable efficiency values working even at partial loads, with the good reliability using as a fuel natural gas or biogenous fuels such as biogas [1,2]. One of the main draw back for these systems is the suffering against trace compounds [3]. These compounds are contained both in biogenous and fossil fuels and degrade the SOFC performance reversibly and irreversibly depending on the concentration and family of the compound considered [3]. The ability to distinguish several isobaric aldehydes, ketones, isoprenoids and other compounds is impossible using a classical PTR-MS instrument. To identify and to monitor isobaric compounds, a Time of Flight detector was adopted, while to identify isomers a new prototype developed by Ionicon was considered. The FastGC prototype allowed for a rapid (90 s) chromatographic separation of the sample headspace prior to PTR-MS analysis. The system was tested on natural gas trace compounds to individuate the major elements and to identify possible issues for the SOFC generators. In comparison to the results obtained by direct injection, FastGC provided additional information, thanks to a less drastic dilution of the sample and due to the chromatographic separation of isomers. This was achieved without increasing duration and complexity of the analysis.

2. Experimental and methods

A PTR-ToF-MS instrument was adopted (PTR-ToF 8000, IONICON Analytik, Innsbruck, Austria). This instrument is already able to provides separation and identification of isobaric compounds through its high mass resolution in real-time [4,5]. However, isomers, compounds with the same exact mass, cannot be separated. The built-in FastGC prototype, realized in Ionicon (IONICON Analytik, Innsbruck, Austria) it is now also possible to separate isomeric compounds in fast spectral runs. In short, in a gas chromatographic (GC) column, compounds are primarily separated in retention time according to their boiling point and can be further separated according to their polarity by choosing a polar column [6]. The complete set-up, described in Romano et al., (2014) is reported in figure 1. A short (3.5 m) nonpolar pure dimethyl polysiloxane GC column (MXT-1, 0.25 mm ID, 0.25 mm df, from Restek, Bellefonte, PA), a custom made valve block, a flow controller, and a heating controller, is built into the PTR-ToF-MS and uses the same sample inlet. The column is resistively heated by applying a current, which allows for fast heating rates (>10 °C/s). The low thermal mass of the heating module also ensures fast cooling rates (from 200 °C to 50°C in less than 20 s). The FastGC mode can be activated when required while not affecting the normal PTR-ToF operation otherwise. During all measurements the ionization conditions in the drift tube were the following: 100 °C drift tube temperature, 2.30 mbar drift pressure, 550 V drift voltage. This led to an E/N ratio of 130 Td ($1 \text{ Td} = 10^{17} \text{ cm}^2 \text{ V}^1 \text{ s}^{-1}$). The inlet line consisted of a PEEK capillary tube (internal diameter 0.40 mm) heated at 100 °C. The inlet flow was set at 100 sccm. Analysis took place at an acquisition rate of one spectrum every 900 ms and 90 ms for direct injection and FastGC, respectively. The switch between direct injection and FastGC measurement modes was carried out by means of the custom made valve block electronically controlled (Fig. 1). The natural gas samples were collected in Nalophan bags from the gas network (Snam rete gas - San Michele a/A). Nalophan bags were selected as preferable to Tedlar bags because they gave a cleaner background, as shown by Beghi and Guillot (2008) [7]. It is noted that for some compounds, such as H₂S, Tedlar bags permit better compound recovery as shown by Hansen et al., (2011) [8]. The injection time was set to 2.5 s. The temperature of the FastGC column was left at the temperature inside the instrument of 35 °C, which was optimal for the separation of the investigated highly volatile compounds.

Download English Version:

<https://daneshyari.com/en/article/5446496>

Download Persian Version:

<https://daneshyari.com/article/5446496>

[Daneshyari.com](https://daneshyari.com)