

## PHOTOACOUSTICS: AN APPROACH FOR ONLINE PROCESS CONTROL OF DEGASSING XLPE INSULATED HIGH VOLTAGE CABLES

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### ABSTRACT

*In this work we present the photoacoustic spectroscopy as a novel technique for online controlling of degassing processes. The degassing was studied on XLPE insulated cables. Since the photoacoustic approach is free of any cross sensitivities, it enables the measurement of trace methane concentrations in the presence of other byproducts generated by the cross linking process.*

### KEYWORDS

Thermal degassing; Gas analytics; Photoacoustic spectroscopy; Gas trace analysis.

### INTRODUCTION

In the process of producing XLPE insulated cables the elimination of byproducts generated in the course of the cross linking process is essential. Major byproducts are acetophenone,  $\alpha$ -methylstyrole, cumyl alcohol and methane. At present the effect of degassing can be measured by thermal gravimetric analyses as described in HD 632. The fulfilling of the document's requirements is considered as sufficient also in respect of the residual methane content that should be less than 30 ppm to avoid undue overpressure and resulting possible damages especially in joint areas of cable systems.

Cables are usually degassed thermally in degassing chambers. Up to now, degassing processes have been pursued by gas chromatography or high pressure liquid chromatography. These methods are limited to discontinuous analyses of samples from end sections of cables and are hardly suitable for online process control. The mentioned methods depend also on various parameters as for instance cable sizes and lengths, drum parameters, and temperature distributions within cables and do not reveal the overall degassing status.

For controlling the degassing process and degassing kinetics in particular, it is desirable to measure the released methane content continuously. In this contribution we present a technique of non-invasive methane detection that is able to provide an online control of the degassing process.

### ACTUAL SITUATION

There are numerous different experimental approaches available to detect low gas concentrations. Beside mass spectroscopy as a universal and very sensitive tool for identifying gas species, several complex laser-based detection methods such as cavity-ring down spectroscopy and intracavity absorption spectroscopy are mainly used for research applications.

FTIR spectrometer have found a wide dissemination. Since they operate in the range of fundamental molecular ground-state vibrations, sometimes problems in distinguishing hydrocarbons do appear.

Mass spectroscopy and most of the laser-based method as well as the FTIR spectroscopy can hardly be considered for on-line diagnostics.

In the analysis of combustion gases on-line sensors are used which are equipped with broadband IR-light sources and optical filters. Since these filters have considerably large spectral bandwidths, different hydrocarbons cannot be distinguished in many cases by their distinct vibrational-rotational transitions.

Since semiconductor gas sensors detect primarily reductive substances, they are not able to detect distinct hydrocarbons.

Gas chromatography or high pressure liquid chromatography as non-spectroscopic methods are very sensitive methods that well separate species in multi-component mixtures but are also not applicable for on-line process control.

Taking all these aspects into account we designed and tested a method capable for on-line process control and free of any cross sensitivities to monitor the methane content of the atmosphere in degassing chambers.

### PHOTOACOUSTICS

The basic methodical idea is the conversion of energy absorbed by sample molecules into heat. The temperature increase of the sample causes an increase of the kinetic energy of molecules. Chopping the excitation light source, the periodic changes in kinetic energy are transferred to sound waves. This effect was independently discovered by Graham Bell [1] and Wilhelm Conrad Roentgen [2] at the end of the 19th century. The spectrophone that G. Bell used within his pioneering work is shown in Fig. 1. Over a long period of time this effect has not been considered for solving spectroscopic problems. A renaissance of this method took place in the seventies of the last century mainly initialized by Allen Rosenzweig who developed a comprising theory to the photoacoustic effect. In the following decades, the method has been applied to various fields of research and applied science as for instance the real time analysis of biological processes [4], the pursue of chemical processes [5] or in the investigation of material properties [6].

The numerous fields of application document that this spectroscopy is not limited to a special phase of matter. In addition photoacoustic spectroscopy includes the ability to obtain optical and thermal properties of solid and semi-