# A SKIN CONTAMINATION SURVEY AT A COAL GASIFIER USING A LUMINESCENCE DETECTOR*



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## ABSTRACT

Skin contamination of workers in synfuel industries may be directly detected using induced fluorescence. The method uses a luminoscope, a portable luminescence detector based upon a fiberoptics lightguide. The lightguide transmits long-wavelength ultraviolet excitation radiation to the skin area being monitored at an intensity 1/100th of the radiant flux of sunlight and conveys the induced fluorescence emission from the contaminant to the detector. The instrument is suitable for detecting trace amounts of various coal tars at the $\mu g/cm^2$ levels. Coal distillate and recycle solvents from liquefaction processes can be detected at a few $nl/cm^2$ levels. The results of a recent field test at a coal conversion facility are reported.

## INTRODUCTION

Each day workers in synfuel plants are potentially exposed to coal tars and oils. Skin contamination by direct contact transfer and/or by surface adsorption of vapors and particulates into the skin is a major pathway of exposure. Measurement of exposure to these coal tar materials is of great importance because these substances contain potentially carcinogenic compounds such as the polynuclear aromatic (PNA) compounds (1). Skin irritant and potential carcinogenic properties of raw syncrudes and their distillate fractions have been reported (2-4). This work involves the design and evaluation of a portable instrument, the luminoscope, for detecting skin contamination by coal tars via induced fluorescence. The instrument has been used in the laboratory to measure the fluorescence of various coal tars and recycle solvents from liquefaction processes spotted on paper surfaces and on hamster skin. Preliminary results indicate that the coal tars and recycle solvents can be detected at a few $\mu g/cm^2$ and $nl/cm^2$ levels, respectively. The performance of the prototype instrument has been recently evaluated at a coal conversion facility.

## THE METHOD: MONITORING SKIN CONTAMINATION BY FLUORESCENCE

The method of monitoring skin contamination using induced fluorescence is not new. However, until now it has only been performed in a coarse manner by simple visual examination in industrial hygiene practices. By this method, the torso and extremities of the worker are illuminated with a hand-held ultraviolet (UV) lamp and the resulting fluorescence is examined with the naked eye in a

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## DISCLAIMER

dark room. The contaminants on the skin are detected when they exhibit a fluorescence signal brighter than that of the skin. This method has several drawbacks. First, the method has to rely upon the sensitivity and discriminating ability of the operator's eye which are obvious subjective human elements. Second, the intensity of the hand-held black light lamp is such that it might cause some concern about the carcinogenic activity of UV light, and the synergistic effects of light and chemicals, even at long UV wavelengths (5,6). For this reason the use of the hand-held black light is presently not recommended for routine industrial hygiene practices on workers. The purpose of this work is to design and fabricate a practical instrument that can employ the sensitive luminescence technique without presenting the above inconveniences and potential health hazards. Considering the importance of the risk associated with skin contamination and the present lack of adequate monitoring instrument, there is an urgent need for such a device.

## THE INSTRUMENT

Figure 1 shows the schematic optical arrangement of the luminoscope. The detailed description of the instrument is given elsewhere (7). Only the main features are given here. Fiberoptic waveguides have been widely used for electrooptic communications but not to as great an extent for analytical luminescence measurements. The purpose of the bifurcated lightpipe (The

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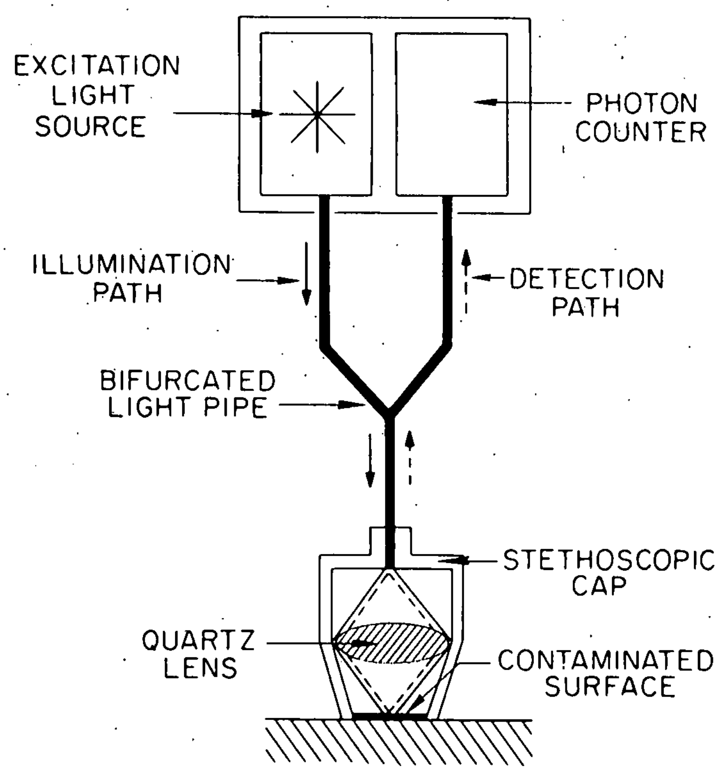


Fig. 1. Schematic diagram of the optical arrangements of the light pipe luminoscope.

Ealing Co.) is to transmit the excitation UV radiation onto the surface area being monitored and convey the fluorescence emission back onto the detector. Ultraviolet light from a small 125-watt mercury lamp (PBL Electro-Optics, Inc., Model HG-125) is focused onto the excitation entrance of the fiberoptics. A filter (The Ealing Co., Model OX1, N-26-3012) transmitting light at 360 nm with a bandwidth of 50 nm was used in conjunction with the source excitation. A set of broad-band interference filters (Rolyn Optics Co.) transmitting light from 400 nm to 700 nm were used for selecting the emission wavelengths at which the fluorescence is to be monitored. All the filters can be easily interchanged. A stethoscopic cap is mounted at the common leg of the bifurcated lightguide.

During the measurement the open end of the stethoscopic cap is pressed against the targeted area of the skin. Safety of operation, simplicity of design and operation, portability, and low cost are the main features sought for the luminoscope. The use of a lightguide to contain the UV light prevents inadvertent illumination of the person being monitored. The flexible fiber material allows the survey of hard-to-reach locations (areas under the neck, chin, underarms) in an easy and practical manner. The intensity of the long-wavelength UV light at 350 nm with a 50 nm band width was set at $10^2$ ergs/nm/sec., e.g., 1/100th of the radiant flux of sunlight (350 nm - 400 nm) at sea level (8). The detector is a miniature photon counting tube (Research Support Instruments, Inc., Model 2G-150).

The digital counting circuits and the digital-to-analog circuits are designed and constructed in-house. The hand-held instrument is low cost (∿ $2,000), simple to operate, and weighs only a little over 1 kg without the power supply. The experimental layout of the instrument is shown in Figure 2.

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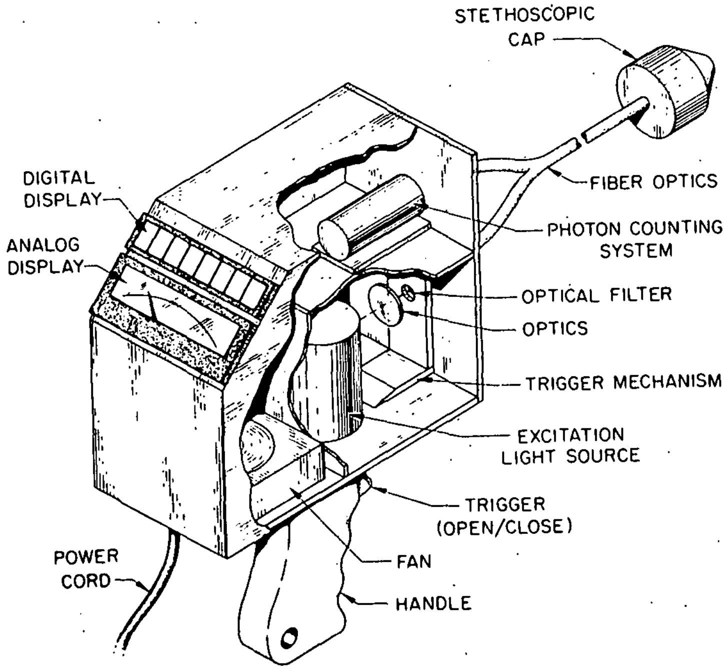


Fig. 2. Layout of the main components of the light pipe luminoscope.

## MEASUREMENTS AND DISCUSSION

Measurements of oils and tars from a variety of processes have been made with the lightpipe luminoscope (7). The instrument is capable of detecting trace amounts of various coal tars at the μg/cm$^2$ levels. Coal distillates and recycle solvents from liquefaction processes can be detected at a few nl/cm$^2$ levels. The measurements of these materials have also been carried out using hamster skin (7). Figure 3 shows the linear relationship between the fluorescence intensity and the amount of the analyte for the solvent recycle coal (SRC-I) produced at low concentration level.

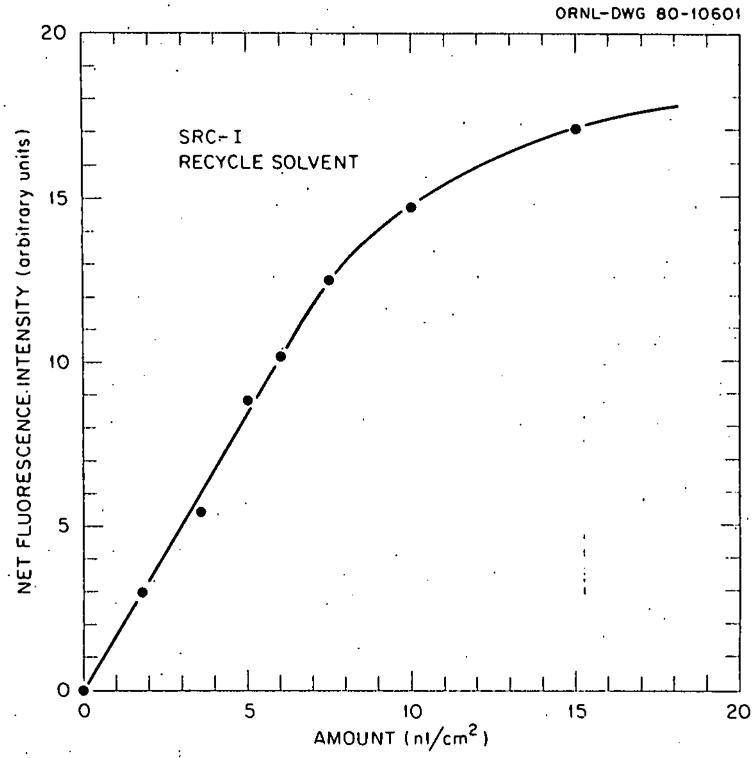


Fig. 3. Variation of the fluorescence intensity detected with the luminoscope with the amount of SRC-I solvent.

Recently the luminoscope was field-tested at a coal gasifier facility. The purpose was to evaluate the performance of the prototype apparatus in a real-life workplace environment and to test the applicability of the instrumental concept in actual measurements. The skin contamination survey was carried out on six workers during two periods of the workshifts. The first series of measurements were performed during the lunch break at noon and the second series of measurements at the end of the day workshift. All measurements were carried out before and after washing. The areas of the workers at this coal gasifier most likely to be directly exposed to coal and tar are those not protected by clothing, e.g., hands, arms, and faces. The measurements performed during this field trip were restricted only to arms and hands.

The field study at the coal gasifier has revealed several important features. Preliminary data indicate that the background fluorescence of clean skin is not constant. It varies by 10 to 35% between two individuals. Background correction is, therefore, necessary to determine the net fluorescence from the contaminant. For each individual, the fluorescence background also varies by 10 to 15%. In addition to this normal background variation, the luminoscope has detected several specific areas in the hands that are highly fluorescent (e.g., $\geq$ 50% above the average signal level). This high fluorescence signal appears to originate from areas where the skin has a different complexion, e.g., callauses, dried skin, and finger tips. It is, therefore, important to keep data files for each individual indicating the highly fluorescent specific areas. Unlike contaminated areas, which also exhibit high fluorescence, the luminescence signal due to skin complexion did not decrease after washing. The instrument recorded two cases of high fluorescence caused by residual contamination. Unlike the fluorescing residual contamination, thick deposits of coal tar and coal dust usually decreased the luminescence background of the skin by absorbing the excitation light. In practice, this type of heavy contamination was visible to the naked eye and did not require the use of the instrument.

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