INVESTIGATION OF THE POSSIBILITY OF USING AN EXCIMER Kr-F LASER IN LIDAR EXPERIMENTS ON DETECTION OF OIL FILMS ON A WATER SURFACE

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The luminescence spectra of several types of petroleum and B-70 benzene in the wavelength range 250...350 nm*, excited with an Kr-F excimer laser, were measured. It is shown that there exists luminescence of these substances in this wavelength range and the shape of the luminescence spectrum of different types of petroleum is different. The results shows that remote laser sounding of a polluted water surface can be performed during the day in this wavelength range.*

An important problem of remote laser sounding is daytime sounding in the presence of strong solar background radiation. The standard methods for attenuating the solar illumination by narrowing the spectral band of the detector cannot be used to record the wideband luminescence spectra of petroleum products. One possible solution of this problem is to use the solar-blind region of the spectrum 220 ... 300 nm. It is well known that the flux of solar radiation in the range 200 ... 300 nm is determined primarily by the Hartley absorption band of ozone and it is equal to about 10^{10} photons/cm^2 · s near 300 nm, which is more than 10^4 times weaker than the flux near 400 nm. For this reason, by working in this spectral range the solar background Illumination can be significantly reduced and by strobing the photodetector with a 1 ... 10 ns strobe, which Is entirely realistic, an additional gain of 8 to 9 orders of magnitude can be achieved.

In this work we investigated the luminescence spectra of benzene and different types of petroleum excited with a Kr-F excimer laser. The wavelength of this laser, equals to 248.5 nm, makes it possible to perform investigations in the above-indicated solar-blind region of the spectrum. The choice of object is determined by the fact that petroleum pollutants are one of the most often encountered pollutants of natural waters and' there are a large number of works, for example, Refs. 1–4, on the problem of using lidar methods for identifying and mapping them.

For these investigations we employed a model 1701 excimer laser operating in the pulsed regime with 60 mJ per pulse, pulsewidth of 12 ns, and pulse repetition frequency of 8 Hz. The laser beam was directed along the normal to the surface of water, and the signal from the sample was recorded at a small angle to the normal; this prevented the laser radiation reflected from the surface from entering the receiving optical system. The radiation from the object was focused on the input slit (100 μm wide) of a polychromator, coupled with the help of changeable diffraction gratings with the detector of am OSA optical multichannel analyzer. A filter was placed in front of .the slit in order to suppress the scattered laser radiation. Luminescence spectra from four oil samples and B-70 benzene were investigated. To do this, several drops of these substances were deposited on the surface of distilled water. The films were 1–1.5 μm thick and the water in the vessel was 13 cm deep. The petroleum samples were taken' from different deposits in the Caspian Sea. Figure i shows the luminescence spectra, In the wavelength range 250 ... 500 nm, of water whose surface is covered with films of benzene and different types of petroleum. A grating with 150 lines/mm was employed. As one can see from Fig. 1, the samples luminescence primarily in the range 300 ... 500 nm, and the luminescence spectra of different types of petroleum have virtually the same form, though the spectrum of the light fractions, in particular, benzene, is shifted toward the shorter, wavelength range. Analogous results were also obtained in Ref. 5. In the region of the spectrum of interest to us the luminescence intensity drops by more than an order of magnitude and was virtually not studied. Although a significant decrease in the luminescence intensity is observed in this region of the spectrum, the signal-to-noise ratio is nevertheless higher than in the region 330 ... 500 nm owing to the significant attenuation of the background solar radiation by the atmosphere. In Fig. 1 the Raman scattering (RS) lines of water (273.3 nm) and the laser line attenuated by the filter can be seen; this makes it possible to calibrate the obtained spectra according to the wavelengths. In addition, in the spectra of "pure" distilled water and water with a benzene film on Its surface one can see the luminescence of dissolved organic substances (DOS), which are unavoidably present in virtually any water.

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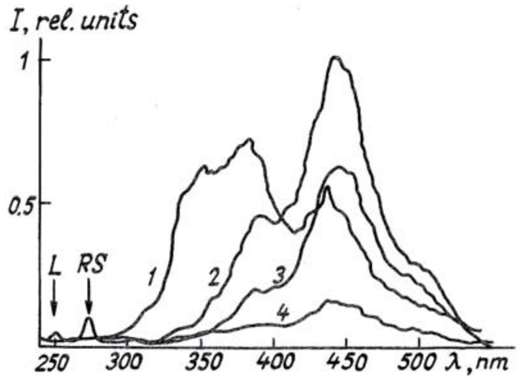

FIG. 1. The luminescence spectra of B-70 benzene (1), two types of petroleum from the Caspian Sea (2, 3), and water (4) at wavelengths in the range 250 ... 500 nm. *The laser radiation line (L) and the Soman scattering lines in water (RS) can be seen in the spectra.*

Figure 2 shows the luminescence spectra of these substances. The spectra were obtained with the help of a high-resolution diffraction grating (600 lines/mm) in the wavelength range 260 ... 325 nm. To make it easier to compare the results of different measurements, the spectra are normalized based on the maximum intensity of the wavelength dependence of the transmittance of the lines. In addition, corrections for thewavelength dependence of the transmittance of the filters were introduced into the spectra presented. One can see from Fig. 2 that in spite of the sharply lower luminescence intensity in this region than in the region 350 ... 500 nm, first of all, petroleum also luminescences in this wavelength range and, second, the emission spectra of different types of petroleum are different. As one can see, the largest difference between the spectra, like in the entire range studied, is observed in the solar-blind region between benzene (light petroleum fractions) and raw petroleum. It should also be noted that the Raman scattering line is seen only for benzene, since the transmission of radiation from water through the raw-petroleum film Is extremely weak.

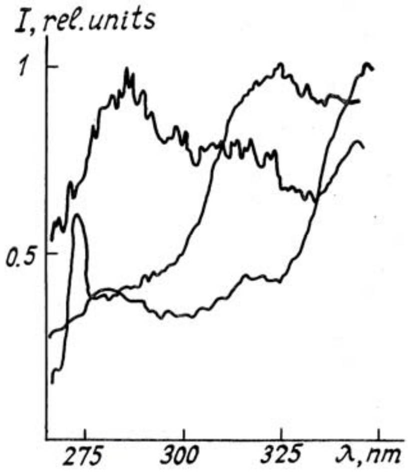

FIG. 2. The luminescence spectra of raw petroleum from the region of the Caspian Sea (1, 3) and of benzene (2) in the wavelength range 260 ... 350 nm. *The spectra are normalized relative to the maximum value.*

Our petroleum luminescence spectra in the range 260 ... 325 nm suggest that daytime investigations of water surfaces may be possible with the help of excimer laser lidars.

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