ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 7, Issue 6 , June 2020

Optoelectronic Methods for Controlling the Physicochemical Parameters of Oil-Containing Media Based on Effects NIE and INGOS

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ABSTRACT: This article gives the basics of optical methods and the principles of constructing multifunctional optoelectronic systems for monitoring the physicochemical parameters of oil-containing media based on the effects of impaired total internal reflection (ATR) and multiple impaired total internal reflection (INRM). Optical systems with the use of the ATR effect and analysis of the main structures of the ATR and MNVO sensors are considered, practical schemes of optoelectronic systems of non-destructive testing based on the ATR and MNVO are given.

KEY WORDS: effects of air defense and air defense, optical systems, air defense and air defense sensors, electronic circuits, optoelectronic systems of non-destructive testing based on air defense and air defense.

I.INTRODUCTION

The refractometric method, based on the determination of the refractive index of the studied media using the effect of impaired total internal reflection (ATR) and multiple impaired total internal reflection (INRM), is characterized by high accuracy, technical simplicity and accessibility. Not inferior to other physicochemical methods in accuracy and the convenience of determining optical parameters, the ATR method surpasses their expressness, while providing non-destructive testing.

The ATR method (Fig. 1) is based on the phenomenon of penetration of a light wave into an optically less dense medium n2, when the light flux propagates from an optically denser medium n1 to a less dense medium n2 at an angle.

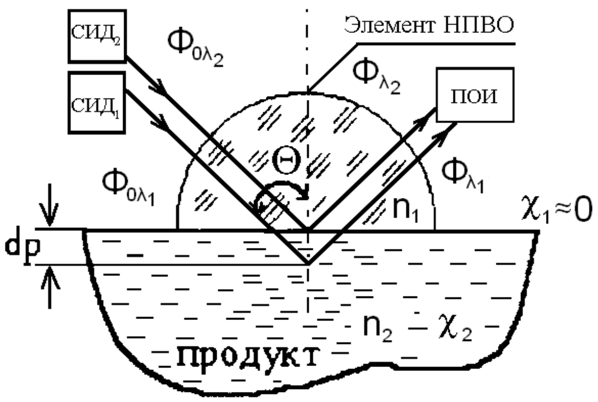

Figure 1 - Physical basis of the ATR method

The physical meaning is as follows. Two light fluxes with different wavelengths are used, for example, □1 = 1.93 μm (measuring) and □2 = 1.7 μm (reference), corresponding to the maximum and minimum water absorption. The

ISSN: 2350-0328
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luminous flux Φ0□ propagates from an optically dense medium with a refractive index n1, into a less dense one with n2 at an angle □ exceeding the limiting (critical) angle of total internal reflection □к ,. The light flux Φ0 Φ1 partially penetrates into the medium n2; to a depth of the order of the wavelength of the incident radiation.

$$d_p = \frac{\lambda_1}{2\pi\left(\sin^2\Theta - n_{21}\right)^{1/2}}$$

where is the radiation wavelength in an optically dense medium with a refractive index n1; n21 = n2 / n1 is the relative refractive index. If the radiation angle is equal to or exceeds the critical к = arcsinn1 / n2, then total internal reflection is observed (air defense method). Since a less dense medium with a complex refractive index: has absorption, the reflection will not be complete, i.e. the conditions for this are violated and the reflection coefficient (R = Φ1 / Φ01) will become less than 1. The degree of attenuation R is proportional to the absorption index. Thus, the higher the absorption, the more reflection is disturbed. This is called the NIP effect. In the infrared region of the spectrum, to achieve the condition n1> n2, the ATRM measuring elements are used from highly refractive optical materials that are transparent in the corresponding range.
They are performed mainly in the form of attachments (called "ATR attachments") to various serial spectrometers and spectrophotometers, where the attachments are installed in the cuvette compartment between the illuminator and the monochromatic. Prefixes are available in two versions: with single reflection or with multiple reflection (MNPVO prefixes). The former is intended for obtaining single-reflection spectra with the possibility of a smooth change in the angle of incidence and are used mainly for research purposes to determine optical constant media. MNPVO prefixes allow to obtain spectra with a large number of reflections and a limited number of fixed incidence angles; they serve mainly for solving analytical problems.
Prefixes MNPVO are intended mainly for analytical purposes, and therefore the element MNPVO and a number of accessories to the prefix are performed taking into account the problem being solved. So, to conduct research in the field of electrochemistry and biology, thin translucent layers of gold and platinum are applied to the working surface of the element. Attachments adapted for liquid chromatography have flow thermostatic cuvettes. The composition of the prefixes intended for the study of films includes a compact paralyzer for spraying in vacuum a substance that forms a film on the surface of an INME element, etc.
The most important optical properties of oil and oil products include optical density, the content of various components of substances and other characteristics that can be controlled using optical methods, including the use of various refractometers.
Oil is characterized by optical absorption values of 0.01 <<0.2. It is possible to achieve conditions under which its optical density would not go beyond the working range that provides satisfactory accuracy of photometric measurements (0.2 <D <0.8) by changing the concentration of the absorbing substance (for example, diluting it with a solvent). The disadvantage of this method is the possibility of random errors and violation of the structure of the analytic.

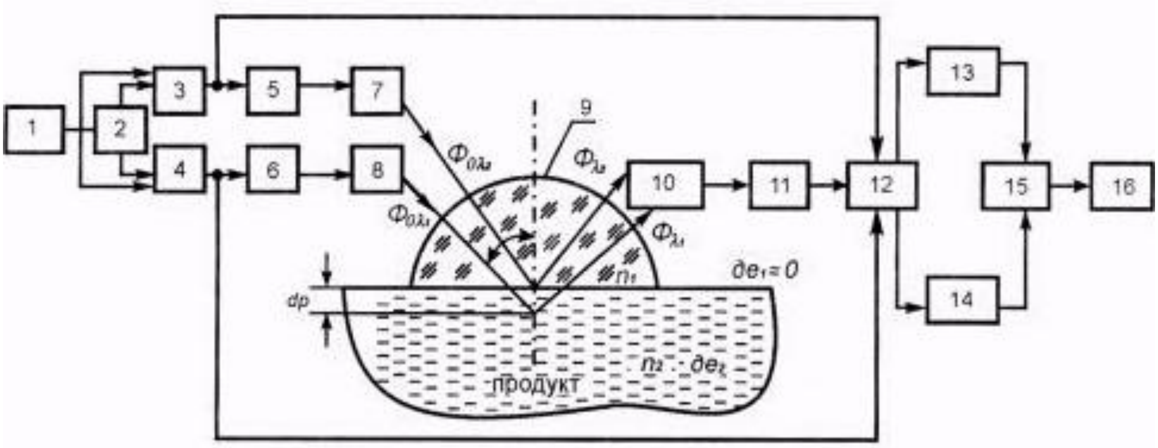

Fig. 2 - Analyzer of the structural-group composition of oil and oil-containing media

The author, based on lenses and an ATR element, developed an optical analyzer of the structural-group composition of oil and oil-containing media (Fig. 2). In accuracy and detail of the determination, it is not inferior to other

ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 7, Issue 6 , June 2020

physicochemical methods, surpasses them in expressivity and simplicity, providing non-destructive testing. The ATR method is usually unsuitable for the study of materials with a strongly varying refractive index (for example, quartz). In these cases, it is not possible to maintain the angle of incidence above the critical angle over the entire wavelength range. In the absence of a sufficiently good contact between the sample and the ATR element, the obtained values of the relative band intensities cannot be considered reliable.
Despite these drawbacks, the ATR method in many cases expanded the scope of application of optical spectroscopy and simplified the measurement technique, in particular, the sample preparation procedure. As confirmation of this, we point out the ease of obtaining the ATR spectra of powders. Another important advantage of the ATR method is the absence of interference bands in the spectrum. The field of application of optical spectroscopy has expanded significantly due to the opportunity to obtain ATR spectra of objects without destroying the latter (for example, spectra of films on absorbing substrates, fibers, fabrics, samples deposited on filter paper, etc.). Another advantage of the ATR method over the transmission method, which has not yet been fully exploited, is the presence of electric fields on the reflection surface in all three spatial directions, which is important when studying anisotropic materials. Apparently, the most important area of application of ATR spectroscopy is the express analysis of oil and oil products.

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