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LASER INFORMATION SYSTEM FOR MONITORING GLUE EVAPORATION DURING DRYING

In the context of advancing technologies in printing, materials processing, and chemical production, there is a growing demand for precision in monitoring volatile emissions generated during drying processes. Conventional control methods often lack the speed, sensitivity, or selectivity required for real-time analysis of adhesive evaporation products, particularly in dynamic industrial environments such as book block drying chambers.

This study substantiates the development of laser-based resonance photometric systems for evaluating the concentration of evaporated chemical components from adhesive mixtures. A methodological framework is proposed for implementing dual-channel laser photometry, enabling non-contact, rapid, and spatially resolved assessment of volatile content. The structure and operating principles of a laboratory-grade concentration meter are presented, incorporating semiconductor lasers, photodetectors, signal processing units, and intelligent control agents.

Special attention is given to the physical and quantum-chemical interactions of laser beams with aqueous media, as well as to the solubility dynamics of adhesive components under thermal influence. A two-stage selective photoionization approach is introduced to enhance signal amplification through resonance effects, enabling more precise quantification of emissions.

The proposed methods can be applied not only to printing production environments but also to broader ecological monitoring tasks involving laser-based diagnostics of airborne and liquid-phase contaminants. These technologies contribute to the development of next-generation intelligent sensing systems capable of supporting environmental safety and process optimization.

Key words: photometry, laser, resonance phenomena, quantum interaction, concentration, drying, adhesive.

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ЛАЗЕРНО-ІНФОРМАЦІЙНО СИСТЕМА ДЛЯ МОНІТОРИНГУ ВИПАРУВАННЯ КЛЕЮ ПІД ЧАС ВИСИХАННЯ

У контексті розвитку технологій у поліграфії, обробці матеріалів та хімічному виробництві зростає потреба у високоточному моніторингу летких викидів, що утворюються під час процесів сушіння. Традиційні методи контролю часто не забезпечують необхідної швидкості, чутливості або вибірковості для оперативного аналізу продуктів випаровування клею, особливо в динамічних умовах, таких як сушарки книжкових блоків.

У роботі обґрунтовано створення лазерних резонансних фотометричних систем для оцінки концентрації випаруваних хімічних компонентів з клейових сумішей. Запропоновано методологічну основу для реалізації двоканальної лазерної фотометрії, що забезпечує безконтактну, експресну та просторово локалізовану оцінку вмісту летких речовин. Представлено структуру та принцип дії лабораторного концентратоміра, який включає напівпровідникові лазери, фотоприймачі, блоки обробки сигналів та інтелектуальні керуючі агенти.

Особливу увагу приділено фізичній та квантово-хімічній взаємодії лазерного променя з водним середовищем, а також динаміці розчинності клейових компонентів під тепловим впливом. Запропоновано двоступеневий підхід до селективної фотоіонізації для підсилення сигналу через резонансні ефекти, що дозволяє здійснювати більш точну кількісну оцінку викидів.

Запропоновані методи можуть бути застосовані не лише у поліграфічному виробництві, але й у ширшому контексті екологічного моніторингу, зокрема для лазерної діагностики забруднень у повітряному та рідинному середовищі. Ці технології сприяють розвитку сенсорних систем нового покоління, здатних підтримувати екологічну безпеку та оптимізацію технологічних процесів.

Ключові слова: фотометрія, лазер, резонансні явища, квантова взаємодія, концентрація, сушіння, клей.

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Introduction

The issue of evaluating the concentration of chemical substances in air and solutions used in technological processes across energy, printing, food industries, and the oil and gas sector is complicated by the structural and compositional complexity of such media. A particularly relevant challenge is the inverse task of estimating the water content in components employed in the technological processes of printing production. An essential management task is to control the solubility of chemical elements in adhesives and the dynamics of their evaporation.

Analysis of recent studies and publications

Solving the problem of ensuring accuracy and stability in optical measurement systems (photometers) is increasingly based on information and systems technologies.

Studies [8–16] examine the fundamental concepts of photometric analysis methods for addressing a broad class of control tasks in technical systems as well as in biophysical and chemical reactors. In [11], synthesis methods for Laser InfoFrmation-Measurement Systems (LIMS) were substantiated for process control in high-temperature environments. The effectiveness of laser probing for a wide range of technologies was demonstrated, especially for investigating the dynamics of chemical reactions.

In [12], the optical properties of chemical solutions and the spectral methods for investigating photoactive media and photometer structures were substantiated. Correspondingly, [13] addressed the application of photoelectron spectroscopy methods in chemistry for obtaining structural information, quantitative analysis, assessment of chemical shifts, and adsorption. A comprehensive analysis of optoelectronic system design methods was discussed in [13–16]; however, the synthesis of laser systems was not covered.

Purpose of the article

The development of methods and tools for express assessment of component concentrations level within the technological environment of book block dryers is a relevant and timely task [1–8].

The widespread application of opto-physical research is based on several advantageous properties: locality, rapidity, non-contact probing using an optical beam, and high informativeness in measuring the characteristics of the interaction medium [8–10]. By its nature, the opto-physical method is a physical experiment in which the optical beam serves as both the carrier and extractor of informative data about the object. The information about the object is generated during the processing of the (laser) optical signal.

It is important to distinguish two components in the data processing procedure:

– the reception and processing of the optical beam image, including recognition of its structure and energy characteristics;

– the reception of the optical signal and evaluation of its energy characteristics, with discrimination of the power density center to estimate reagent concentration within the technological medium.

Existing optical radiation sources do not provide a clearly defined directional diagram; therefore, laser probing of the object may serve as an effective method.

Main research content

Methods for studying laser effects in the process of probing technological environments

Characteristics of the laser beam during probing as the basis for synthesizing laser information-measurement systems (LIMS)

When a laser beam passes through a flat-layered sample [8], the intensity of the incident beam is attenuated due to absorption, reflection, and scattering. The beam's propagation is described by several coefficients (Fig. 1):

– Specular reflection from the surface region of the probed volume $\rho_3 = \frac{\Phi_3}{\Phi_0}$;

– Absorption of the beam within the probing medium $\alpha = \frac{\Phi_n}{\Phi_0}$;

– Surface scattering at the concentration front of reagents $\rho_p = \frac{\Phi_1}{\Phi_0}$;

– Diffusive transmission through the reagent layer of the controlled drying environment $\tau_R = \frac{\Phi_2}{\Phi_0}$;

– Directed transmission of the laser beam through the monitoring path of the drying chamber $\tau_L = \frac{\Phi_4}{\Phi_0}$.

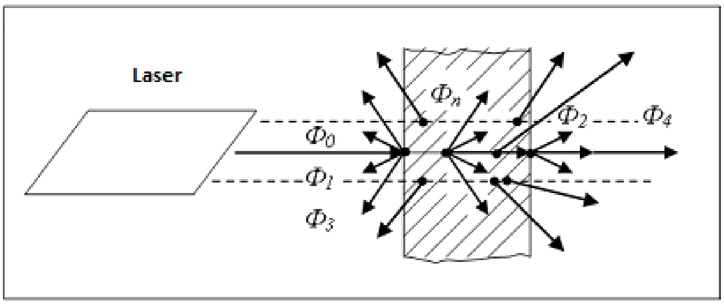

Fig. 1. Structure of the photon scattering microvolume

An energy balance condition for the laser beam must be satisfied: $I_0 = \sum_{i=1}^{n=4} I_i$, $\sum_{i=1}^{2} \tau_i + \sum_{j=1}^{2} \rho_j + \alpha = 1$

Where $I_i \to K_E^i \Phi_i$ the energy of the laser beam is linked with the intensity and the flux function $\Phi(s,t)$ across its cross-sectional area.

According to the Bouguer–Lambert–Beer law for a monochromatic laser beam, the transmitted flux is expressed as:

$$\Phi_\lambda = \Phi_0 \exp(-c_r \varepsilon_\lambda l) \tag{1}$$

where: ε_λ — absorption coefficient at wavelength λ, l — thickness of the substance layer, c_r — concentration of the substance in solution (or specific density).

When accounting for scattering on the walls of a cuvette with the solution, the incoming flux is:

$$\Phi_\lambda(t,c,\theta) = \Phi_0(t)(1-2\rho(\theta,t))\exp(-c,\varepsilon_\lambda,l) \tag{2}$$

where: t — flux fluctuations over time, θ — scattering coefficients on each cuvette surface.

Synthesis of an algorithm for measuring vapor concentration during drying

The medium's properties can be described through concentration dynamics during active chemical reactions:

$$c_r = c_r(\beta,t) \tag{3}$$

and through transmittance and optical density:

$$\tau_\lambda = [\Phi_\lambda / \Phi_0] = \exp(-c_r \varepsilon_\lambda l)$$

$$D_\lambda = \lg[1/\tau_\lambda] \tag{4}$$

The scattering coefficient may be expressed as:

$$\rho_p = [\Phi_p / \Phi_0] = k c_r V_s^{\,2} / \lambda^4 \tag{5}$$

where: V_s — volume of the probed environment captured by the laser beam, λ — wavelength, k — material-specific coefficient.

Concentration dynamics influenced by external factors and non-equilibrium exchange processes:

$$c_r(F_i,t,\theta)_{T_0} = \left[\lambda^u \underset{\substack{\uparrow \\ \left[F_i(t,\theta),T_{0c}^0\right]}}{\rho_p} / kV^2\right] \tag{6}$$

where T_{0c}^0 is the temperature of the medium; and $F_i(t,\theta)$ represents the dynamic influence factors.

Mass of the absorbing substance (transparent medium or solution) is calculated by:

$$M_r = DS / k = -(lg\,\tau)S / k \tag{7}$$

where: S — photometric area, k — material-specific coefficient.

Signal proportional to the solution concentration:

$$U(c_r) = \mu_c^u\left[k_1 I_{r_1}(c_r,t,\theta) - k_2 I_{r_2}(c_{re})\right] = k_I \varDelta U(t,c_r) \tag{8}$$

where: μ_c^u, k_1, k_2, k_I — conversion coefficients from optical to electrical signal.

Selection of the structure of the laser information-measurement system (LIMS)

Based on the above relationships, we synthesize the block diagram of a dual-channel monochromatic laser photometer (Fig. 2), which takes into account formulas (5, 6, 7, 8) and relies on the method of remote probing of the studied and reference environments. This serves as the foundation for creating a laboratory test bench and an information-measurement system (IMS) for experimental studies.

The structural diagram includes the following components:

- Power supply unit for semiconductor lasers NPL_1 and NPL_2;
- Power supply for the laser beam modulator M;
- Reference cuvette (RC) and test cuvette (TC);
- Laser beam photodetectors (PD);
- Band-pass filters for the modulated signal (BF);
- Analog signal processing unit (ASPU);
- Measurement instruments-indicators (HL1, HL2);
- Digital signal processing unit;
- Data acquisition and registration system with a database (DB) and interpretation module;
- Modulation frequency generator (MFG);
- Intelligent experiment agent (IEA);
- Concentration scale selector (CSS);
- Laser power regulators (Var P_1l, Var P_2l);
- Digital signal processing unit for concentration parameter "C_K" (DSPU(C_K));
- Analog-to-digital converter (A/D);
- Analog signal level indicator for photometer calibration with a concentration standard.

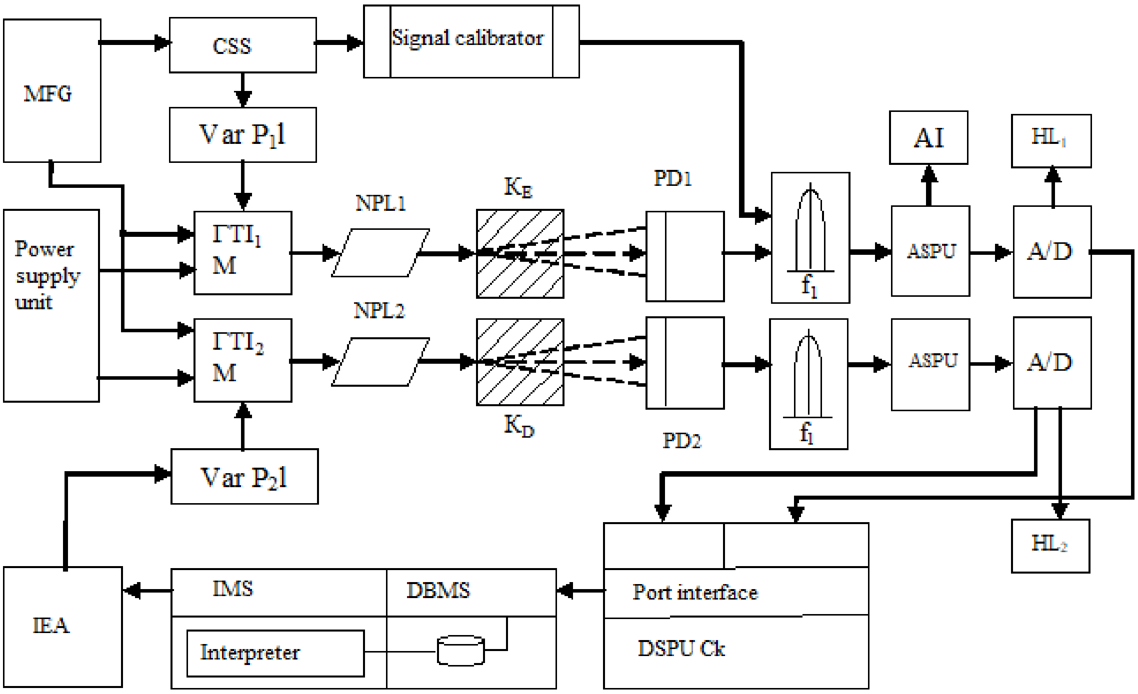

Fig. 2. Block diagram of a dual-channel laboratory monochromatic laser photometer

The spatial-temporal concentration change signal of liquid or air condensate during physics-chemical transformations is formed according to the algorithm [15]: $Z_S = Z_C \times \alpha_S(C_K, P_L, \theta_K)$, where: Z_S — signal at the output of the reagent cuvette, Z_C — probing signal.

To evaluate parameters, calibration using reference media is conducted, after which the concentration and scattering/absorption coefficients are derived.

When probing solutions that may have active or passive (absorbing) media, the following processes occur (if the laser power is sufficient to excite molecules) (see Fig. 3):

– Absorption and scattering of the laser beam within the cuvette k_p containing liquid with suspended solid particles m_k.The photodetector output signal is S

$$U_I(c_r) = \mu_u k_s I(c_{r_1}, \tau, \theta) = \mu_u k \int_{S_{\Phi\Pi}} W(I(x, y, t/c_r))ds,$$

where: $W(I(x, y, t/c_r))$ — power density distribution function of the beam, $W_Y(\ )$— scattering distribution function.

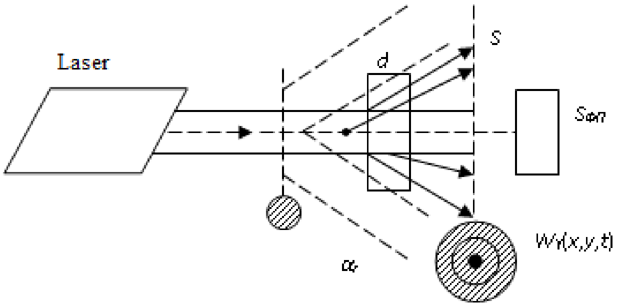

Fig. 3. Formation of the laser probing cone in a scattering medium

– Amplification of the laser signal due to the nonlinear effect of molecular orbital oscillation of active components present in the solution $U_I(c_r, \theta, t) = \mu_u k_s (1 + k_A) \int_{S_{\Phi\Pi}} W(I(x, y, t/c_r^A))ds$, where k_A is the coefficient of active amplification resulting from resonance with the laser beam frequency, and $S_{\Phi\Pi}$ is the area of the photodetector;

– When probing optically transparent objects, the laser beam is absorbed within the solid sections of the object's components.

The intensity of the laser signal is determined based on the evaluation of the power of the scattered beam, which is projected through the condensed medium or cuvette onto the photomatrix (see Fig. 4): $I(x,L)=\int\limits_{S_{\Phi\Pi}} W_S(I(x,y,t/\tau_L,\theta))ds$

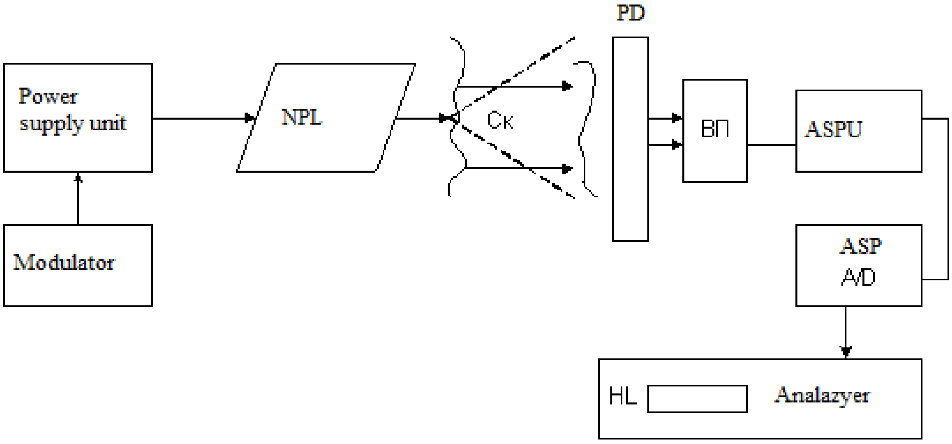

Fig. 4. Block diagram of the laser concentration meter

Amplification of the laser signal due to activation centers excited by laser pulses along the direction of the laser beam $I(x,L)=(1+k_A(L,\theta))\int\limits_{S_{\Phi\Pi}} W_S(I(x,y,t/\tau_L,\theta))ds$, where: τ_L is the transmission coefficient at the slice thickness L of the investigated object; $k_A(L,\theta)$ is the amplification coefficient resulting from nonlinear effects in resonance with the laser beam frequency; $W_S(\ )$ is the transfer function of the medium with volume V_S.

According to the above analysis, a laboratory concentration meter scheme has been developed, which can be used for the study of both liquid solutions and vapor-saturated technological environments (see Fig. 4).

Analysis of the solubility problem of chemical components in adhesive mixtures

A review of various methods of chemical analysis and photometry shows that solving this class of tasks requires the use of laser photometry techniques, primarily due to their high mobility. Historically, laser methods were not widely used because gas lasers were large and required significant power. However, the advent of low- and medium-power semiconductor lasers made their use in photochemistry and photometry feasible.

To solve the problem of controlling both solubility rate and evaporation dynamics, it is necessary to examine the physicochemical structure of water and assess the quantum interaction of the laser beam with the electronic structure of water (Fig. 5).

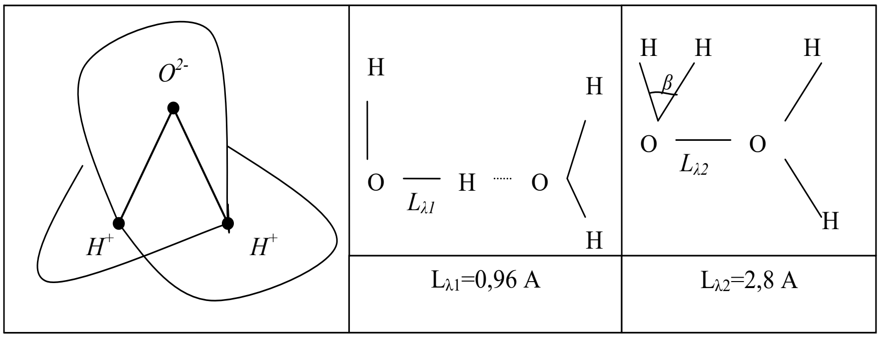

Fig. 5. Structure of hydrogen bonds in water

The electrostatic model of the water molecule using the Rowlinson potential [9] is shown in Fig. 6 and is characterized by the energy of intermolecular interactions (U).

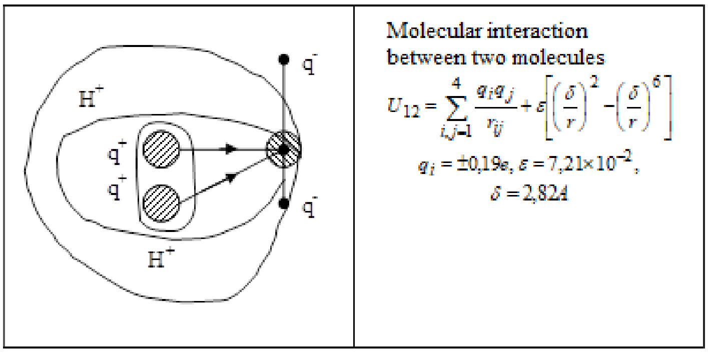

Fig. 6. Electrostatic model of the water molecule based on the Rowlinson potential

The orientation polarization of water molecules in an electric field E along the Z-vector is expressed as:

$$F_1(\cos\theta) = \frac{1}{2\pi Z}\exp(-U\cos\theta / KT) \tag{9}$$

$$Z = \int_{-1}^{1} \exp(-U(X)/KT)dX$$

The intermolecular interaction potential depending on the orientation angles of molecules $(\Omega_1\Omega_2)$ is given by:

$$U(r\Omega_1\Omega_2) = 4\varepsilon\left[\left(\frac{\delta}{r}\right)^{12} - \left(\frac{\delta}{r}\right)^{6}\right] + f(r)\sum_{i,j=1}^{n}\frac{q_i q_j}{r_{ij}} \tag{10}$$

The behavior of a homogeneous chemical system over time can be described by a nonlinear differential equation and visualized as a sequence of stages:

$$\frac{dx_i}{dt} = \dot{X}_i = \sum_{r=1}^{K}\left(\nu'_{ir} - \nu_{ir}\right)\left(\quad \Pi X^{\nu}_{jir}\right)Kr$$

$$\nu_{ir}X_i \xrightarrow{K_r} \nu'_{jr}X_{j,}\ i,j \in N,\ r \in R$$

$$\nu_r = Kr\prod_j X^{\nu}_{jir} \tag{11}$$

where: X_i – type of chemical substance, ν_i — stoichiometric coefficient, K_r — reaction rate constant, $U(r,\Omega_1,\Omega_2)$ — intermolecular interaction potential.

Multi-stage reactions with n-elements can be represented as a dynamic system (Falda's oregonator model) based on the Belousov–Zhabotinsky model [10]: $\begin{cases}(A+Y)\xrightarrow{K_1}(X+P),\\(X+Y)\xrightarrow{K_2}(2P),\\(A+X)\xrightarrow{K_3}(2X+2Z),\end{cases}$ $\begin{cases}2X\xrightarrow{K_4}(A+P),\\Z\xrightarrow{K_5}(hY)\end{cases}$ and the dynamic model over time is represented as $\begin{cases}\dot{X} = K_1AY - K_2XY + K_3AX - 2K_4X^2,\\\dot{Y} = -K_1AY - K_2XY + hK_5Z,\\\dot{Z} = 2K_3AX - K_5Z\end{cases}$

Thus, the time evolution of a homogeneous chemical reaction during the drying of glue-applied products is governed by a nonlinear function: $\dot{X}_j = F_j(X_i),(i,j) \in N$ which describes the thermodynamic equilibrium of the glue layer evolution process.

In experimental evaluation of glue solubility dynamics using laser probing, the fixed component is modeled as entering a solution. This simulates an impulsive disturbance in the cuvette, where concentration changes during the solubility process. The dynamic equation for concentration change during glue formation is:

$$\dot{X}_j = F_j(X_i) + \frac{1}{\tau}\left(X_j^0 - X_j\right), i,j \in N$$

$$\begin{aligned}&Vqcr(T - T_0) - U(T' - T) = [V_R(\Delta Hp\exp(-E/RT))] + \\ &+[VqX_0(Vq + V_Rp\exp(-E/RT))],\end{aligned} \tag{12}$$

where: X_j^0 — initial concentration, τ — time constant of the reactor cuvette, $(\tau = Q_R / V_q)$ — Q_R cuvette volume, V_q — mass flow rate. Additional parameters include: V_q — mass flow rate, C — specific heat capacity, r — specific density of the reagent, X – concentration T — temperature, $U = S_n / RT$ — flow heat transfer coefficient, V_R - reactor volume, H — heat of reaction (energy).

The solubility process of glue components is accompanied by chemical changes in the structure of the reagents, which is required for the technological process of drying printed products, including:

- Molecular transformations;
- Ionic dissociation $\left[(KX_i + H_2O) \overset{\rightarrow}{\leftarrow} K^+(H_2O)_n + A^-(H_2O)m \right]$;
- Formation of fine-dispersed complex components.

Laser activation of the drying process for printed products

When exposed to a laser beam, monomolecular decomposition of the form $[ABC + H\gamma \rightarrow AB + C]$ can occur, as well as the stimulation of chemical reactions through ionization, dissociation, and the excitation of electronic and molecular vibrations in both resonant and non-resonant regimes (see Fig. 7).

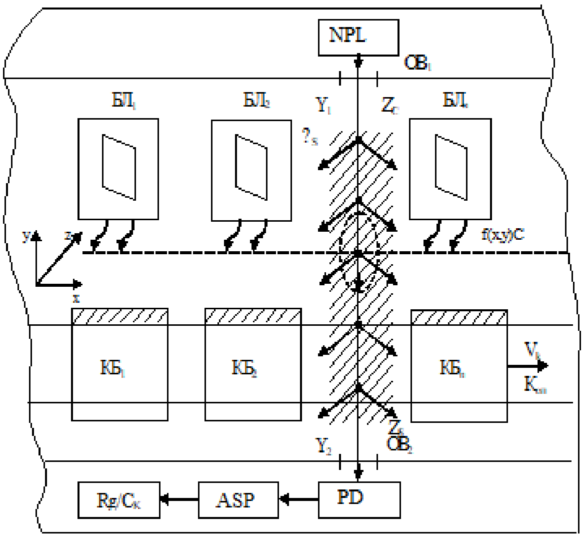

Fig. 7. Experimental setup for activation of the drying process and laser-based monitoring of chemical compound emissions during the drying of printed products

Notation: $T(X,Y)C^0$ - thermodynamic field in the plane $(X \times Y)$; Блi - block of laser photon energy emitters; NPL - laser for concentration control; PD - photodetector; ASP - signal processing unit; $Rq(C_K)$ - recorder.

Under laser impulse action and energy interaction with the chemical component, the dynamic equations take the form: $dX_i / dt = a_1 - b_1 X_i - C_1 X_i \exp(-E / RT)$ $dT / dt = a_2 - b_2 T + C_2 X_i \exp(-E / RT)$ where T is temperature and E is the activation energy.

The ion distribution in untreated freshwater [1], which can be used as a solvent $\left[HCO_3^- > SO_4^{-2} > Cl^-; Ca^{+2} > Mg^{+2} > Na^+\right]$, is referenced. Table 1 shows the concentration of chemical substances in precipitations across the European region (in mg/L). Consequently, an aqueous adhesive mixture includes both soluble and insoluble components responsible for the adhesion process.

Table 1

Concentration of chemical substances in precipitations across the European region

Element	Concentration Range (mg/L)	Max Concentration (mg/L)
Ca2+	0,6 ÷ 23,0	43,0
Mg2+	0,2 ÷ 4,1	15,0
Na+	0,5 ÷ 13,3	33,0
HCO-3	1,5 ÷ 40	5,90
SO2-4	3,6 ÷ 22,1	54,1
Cl-	0,8 ÷ 24,4	65,0
K+	0,4 ÷ 1,5	5,0
$\sum_c^i$ Total ions	7,6 ÷ 114,0	305

Two-stage selective photoionization of adhesive compounds during drying

Two-stage selective photoionization enables the activation of a compound's energy structure through successive exposure to photons from laser radiation (Fig. 8).

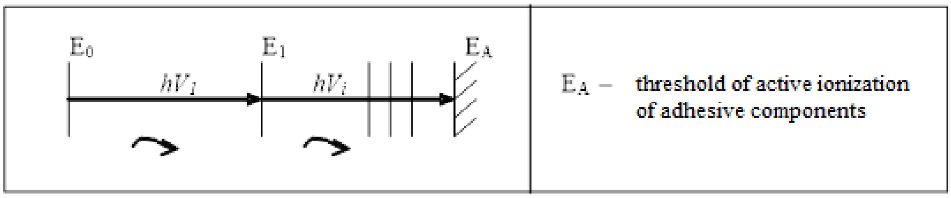

Fig. 8. Two-stage selective photoionization

The reaction of monomolecular decomposition due to interatomic selectivity of excitation can proceed as a chain: $ABC + h\nu_i \rightarrow AB + C$ where A,B,C are reagent components.

Infrared or red laser radiation absorbed by a molecule efficiently excites high vibrational levels up to dissociation and pre-dissociation thresholds (isotonic selectivity), at laser powers of (2–50) MW/cm and pulse durations of 100 ns.

This results in direct energy absorption by the molecular structure, with the number of atoms in the structure defining the energy steps. The following molecular processes occur under laser influence:

- Isomerization and excitation of electronic states $\langle\langle \rightarrow OSO_4 \rangle\rangle, \langle \rightarrow SiF_1 \rangle$;
- Molecular ionization $\langle \rightarrow BCl_3^* \rangle, \langle \rightarrow SiF_4^+ \rangle$;
- Change in rotational energy of vibrational states (see Fig. 9).

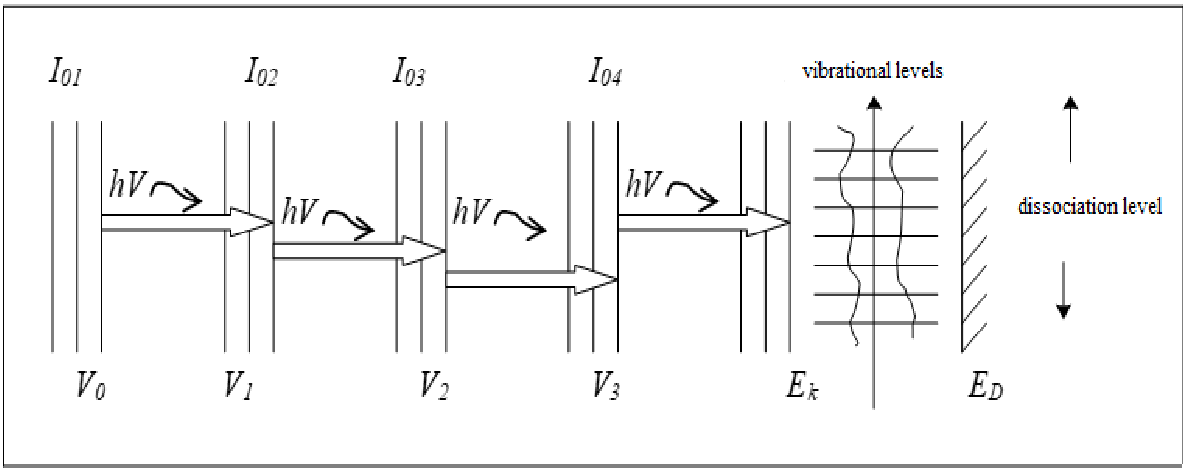

Fig. 9 Multi-step vibrational dissociation of molecules under the influence of a laser beam, which involves photon scattering through a technological medium

Such activation occurs in compounds containing functional groups like $\langle B, S, BCl_3.SF_6, H, Si, C, Cl, Mo \rangle$ and also in triatomic molecules such as $\langle OCS, O_3, NO_2 \rangle$.

Multi-step dissociation under the influence of the laser in strong infrared fields ensures selectivity of excitation. During the process, collisions between molecules maintain the energy balance between laser excitation and the thermodynamic state of the system.

Laser-induced vibrational excitation of a reactant significantly influences the reaction rate during drying [5]. The reaction rate constant is given by: $K = K_0 \exp\left[-\left(E_Q - \alpha E_K\right)/RT\right]$

where $\alpha \in [0{,}3 \div 0{,}6]$ - – for endothermic reactions, $E_K \in [2{,}5 \div 9{,}0]$ kcal/mol – photon energy in the visible range of laser beam generation.

In polyatomic molecules, energy is quickly redistributed among vibrational modes, making excitation non-selective and distributed within $\tau \in [10 \div 100] \times 10^{-9}$ s.

Under electronic excitation, atoms and stable molecules can become chemically active. In the 200–600 nm photon wavelength range, quantum energy lies between 600–200 kJ/mol. Under laser exposure, water molecules can dissociate, as shown in [6] $3\left(\lambda = 242нм : H_2O \rightarrow H + OH\left(^2\Pi\right)\right)$.

To assess the solubility rate of chemical components in water, laser resonance scattering and photometry are used — by comparing input and output probing signal energy (as illustrated in Fig. 7).

Diagram of information-energy transformations and experimental results

According to the model (see Fig. 10), the diagram of laser signal transformation during environmental probing is presented as $P_L \rightarrow A(C_K, R) \rightarrow P_S \rightarrow U_S \rightarrow \phi \rightarrow \hat{C}_K$, and the calibrated characteristic of the concentration function C_K according to model (1) is shown in (2) in accordance with the variation of laser power (P_L) (3):

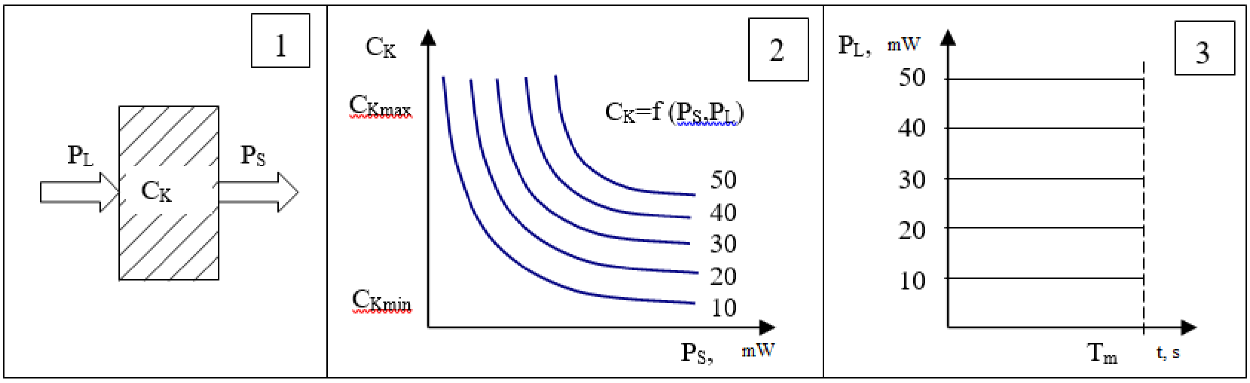

Fig. 10. Diagram of information-energy transformations of the laser signal during medium probing

This diagram demonstrates how the level of concentration (C_K) and evaporation rate of water and reagents is determined via the following relations for laser probing and scattered signals: $Z_S^{Y_2}(t, C_K) = Z_C^{Y_2}(t) A(C_K, \theta, X, y, Z)$ $P_S(y_2, t, C_K) = P_C(X, Y)\alpha(Y, C_K, K_r)$ $U_{\Phi\Pi}(Z_S, Y_S, C_K) = K_{PS} P_S(\phi_S, C_K, l)$ where: $C_K = \phi(U_{\Phi\Pi}(Z_S, Y_S, C_K, t)) \cdot R_{m\partial}$, $Z_C(Y_1)$ - probing signal, $Z_S(Y_2)$ — laser's received signal via optical windows OP1, OP2 and the technological medium, P_C — laser power in the concentration and medium component monitoring system, P_S - received laser signal of the photodetector, PC – photodetector, $U_{\Phi\Pi}$ — photodetector voltage, R_{nl} — conversion coefficient between voltage and concentration based on the measurement function $\phi(\ )$, which defines the transformation in the measurement process.

Table 2 presents the results of an experiment assessing the solubility of chemical components using the method of laser resonance photometry, based on evaluating the dynamic changes in the concentration of a moist medium.

Table 2

Experimental Results of Laser Resonance Photometry

Experiment No.	Readings Over Time (Every 10 sec)									
1	0,40	0,41	0,40	0,41	0,39	0,41	0,38	0,41	0,45	0,47
2	0,36	0,53	0,77	0,78	0,97	0,89	0,96	0,97	0,86	0,88
3	0,79	0,82	0,83	0,92	0,83	0,79	0,76	0,74	0,77	0,97
4	0,70	0,65	0,73	0,75	0,74	0,84	0,86	0,82	0,90	0,94
5	0,18	0,29	0,57	0,63	0,69	0,59	0,69	0,70	0,64	0,60

Conclusion

This article examined the possibility of developing laser-based resonance photometers for evaluating the evaporation rate and concentration of chemical elements in adhesive compounds during the drying of book blocks. It analyzed resonance interaction models in laser control of solubility for chemical components and pharmaceutical substances in aqueous media.

It was demonstrated that the laser resonance photometry method is an effective tool for express analysis of impurities in water, and can be a critical instrument for data acquisition in emergency situations requiring assessment of water contamination levels.

The proposed method and equipment are efficient tools for studying processes in liquids, oils, transformer oil, and aqueous environments, with potential applications in energy, ecology, pharmacy, and biochemical research [17].

Based on the measurements of $k_A(L, \theta)$ and $\tau(c_r)$, one can determine the activity of the medium, where the following interactions occur: $R(\Omega)$ — scattering within a solid angle Ω, $\Pi(L)$ — absorption along the path L of the laser beam, $k_A(L, \theta)$ — amplification along the beam path L, $F(R, \Pi, k_A)$ — composite interaction of the laser beam with the substance.

Measurement of these interactions is determined by the structure of the photometer as an optical information-measurement system.

Author Contributions

Conceptualization O.F.; methodology O.F.; validation O.F.; formal analysis, O.F.; investigation, O.F.; writing - original draft preparation, O.F.; writing - review and editing, O.F.; visualization, O.F.; project administration, O.F.

Declaration on the use of generative artificial intelligence tools

In preparing this work, the author used Grammarly for: grammar and spelling checks. After using this tool/service, author reviewed and edited the content and take full responsibility for the content of this publication.

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