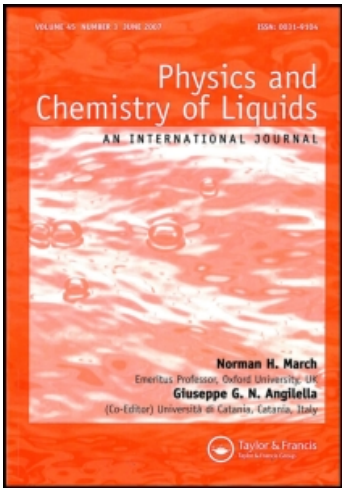

Physics and Chemistry of Liquids
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713646857

Magnetooptical characterization of human blood serum: correlation between neoplasmic changes and their biomolecular information carriers

M. Surma[a]
[a] Department of Physics, Optics Laboratory, Adam Mickiewicz University, 61-614 Poznań, Umultowska 85, PL

To cite this Article Surma, M.(2007) 'Magnetooptical characterization of human blood serum: correlation between neoplasmic changes and their biomolecular information carriers', Physics and Chemistry of Liquids, 45: 3, 271 — 279
To link to this Article: DOI: 10.1080/00319100600620912
URL: http://dx.doi.org/10.1080/00319100600620912

Physics and Chemistry of Liquids
Vol. 45, No. 3, June 2007, 271–279

Taylor & Francis
Taylor & Francis Group

Magnetooptical characterization of human blood serum: correlation between neoplasmic changes and their biomolecular information carriers

M. SURMA*

Department of Physics, Optics Laboratory, Adam Mickiewicz University,
61-614 Poznań, Umultowska 85, PL

(*Received 16 December 2005; revised 27 January 2006; in final form 4 February 2006*)

This article reports a method of gathering information on a neoplasmic disease on the basis of direct magnetooptical analysis of human blood serum. In a strong magnetic field **B** and optical field **k**, biomolecules carrying the information on the neoplasmic changes in human blood serum generate transitions following from their multipolar optical polarizability. The results of the study introduce magnetooptical characteristics of the neoplasmic changes in information carrier. The proposed magnetooptical technique for detection of neoplasmic changes requires a sample of human blood serum of about 2 mL and the availability of a strong magnetic field (10–30 T).

Keywords: Human serum; Magnetooptical characteristics; Neoplasmic changes

1. Introduction

The magnetooptical circular birefringence (MOCB) induced in a chiral medium, measured at the angle of the light polarization plane rotation, is described [1,2] in the parallel ($\mathbf{B} \uparrow\uparrow \mathbf{k}$) and antiparallel ($\mathbf{B} \uparrow\downarrow \mathbf{k}$) configurations of **B** and **k**, where **k** is the wave vector of light propagation in the chiral medium in a magnetic field **B**. The medium studied in this work is human blood serum. The latter is an optically active substance, i.e. it naturally causes a rotation α of the polarization plane of the light passing through it to the right ($\alpha > 0$), so it is a dextrorotatory medium. For homogeneous chemically pure dextrorotatory media, the rotation is positive ($\alpha^+ > 0$), while for laevorotatory media it is counterclockwise ($\alpha^- < 0$) [3]. All blood serum samples are characterized by a resultant dextrorotatory natural optical activity. It means that among all chiral species present in blood serum the dextrorotatory ones α^+ are dominant while the laevorotatory α^- are unmeasured, so that the total effect of serum natural activity is $\alpha = \alpha^+ + \alpha^- > 0$. The physical basis of the proposed MOCB method is that the magnetooptical circular birefringence in human blood serum from healthy donors differs from that recorded for the blood serum from cancer patients. The

*Email: msur@amu.edu.pl

Physics and Chemistry of Liquids
ISSN 0031-9104 print/ISSN 1029-0451 online © 2007 Taylor & Francis
DOI: 10.1080/00319100600620912

effect of the MOCB induced in the blood serum of a cancer patient are measured at the angle $\alpha^{\uparrow\uparrow}$ of the light polarization plane rotation in the configuration ($\mathbf{B} \uparrow\uparrow \mathbf{k}$) described as:

$$\alpha^{\uparrow\uparrow} = (aB + b^{(-)}B^2 + cB^3)L, \tag{1}$$

while for healthy people

$$\alpha^{\uparrow\uparrow} = (aB + b^{(+)}B^2 + cB^3)L. \tag{2}$$

The angle $\alpha^{\uparrow\downarrow}$ measured in the configuration ($\mathbf{B} \uparrow\downarrow \mathbf{k}$) for the blood serum of a cancer patient is

$$\alpha^{\uparrow\uparrow} = (-aB + b^{(-)}B^2 - cB^3)L, \tag{3}$$

and for healthy people

$$\alpha^{\uparrow\downarrow} = (-aB + b^{(+)}B^2 - cB^3)L. \tag{4}$$

The values $b^{(+)}$, $b^{(-)}$ in equations (1–4) determined on the basis of the experimentally measured $\alpha^{\uparrow\uparrow}$ and $\alpha^{\uparrow\downarrow}$ provided clear evidence of differences in the induced circular birefringence between the sera of healthy people ($b^{(+)} > 0$) and the sera of patients with cancer ($b^{(-)} < 0$). This statement is supported by the results [1,4–6] obtained for patients clinically diagnosed by standard medical treatment and by analysis of their serum magnetooptical characteristics, since $b^{(+)}$ and $b^{(-)}$ stand for the magnetic field induced circular birefringence of chiral media in B^2 field. The parameters 'a' and 'c' stand for the Faraday effect and non-linear Faraday effect respectively, while L is the light path in the blood serum sample.

2. Experimental

The experimental magnetooptical techniques require the availability of a strong magnetic field of B from 10 to 30 T. The values of the magnetooptical parameters $b^{(+)}$ and $b^{(-)}$ were measured for about 700 blood serum samples. The experimental result $\alpha^{\uparrow\uparrow} > \alpha^{\uparrow\downarrow}$ indicates the unneoplasmic case because $b^{\exp} = [(\alpha^{\uparrow\uparrow} + \alpha^{\uparrow\downarrow})/(2B^2L)] > 0$, as the term $(\alpha^{\uparrow\uparrow} + \alpha^{\uparrow\downarrow})$ is positive [cf equations (2) and (4)]. For the experimental result $\alpha^{\uparrow\uparrow} < \alpha^{\uparrow\downarrow}$, the value of $b^{\exp}$ value is negative: $b^{\exp} = [(\alpha^{\uparrow\uparrow} < \alpha^{\uparrow\downarrow})/(2B^2L)] < 0$, since the term $(\alpha^{\uparrow\uparrow} < \alpha^{\uparrow\downarrow})$ is negative [cf equations (1) and (3)]. The latter is related to a neoplasmic case. The human serum samples studied in this work have been irradiated with an argon laser beam having wavelength $\lambda = 488$ nm, at $T \approx 295$ K. The laser path in the serum was $L = 5$ mm and the effective excitation volume of the serum was $V_{\text{eff}} = 15.7\,\text{mm}^3$.

The magnetooptical rotation $\alpha(B^2)$ induced by the B^2 field in the serum sample studied can be described as

$$\alpha(B^2) = B^2 L b^{\exp} = B^2 L\left(b^{(+)} + b^{(-)}\right), \tag{5}$$

where $b^{(+)}B^2L = {}^{(+)}\alpha(B^2)$ and $b^{(-)}B^2L = b^{(-)}\alpha(B^2)$.

The negative experimental value of the $b^{\exp} \equiv b^{(-)} < 0$ is characteristic of neoplasmic changes [1,4–8]. As follows from the data of [2] and [9], it is assumed that the multipole transitions in the biomolecule are governed by the negative values of $b^{\exp}$ (MOCB

Table 1. The positive predictive value (PPV) of MOCB results for ovarian cancer, prostate cancer and prostate inflammation.

	Ovarian cancer (%)	Prostate cancer (%)	Prostate inflammation (%)
PPV	76 ($b^{exp} < 0$)	100 ($b^{exp} < 0$)	100 ($b^{exp} > 0$)

effect). Here, we surmise that such multipole transitions carry relevant information on the neoplasmic changes. The MOCB effect implies $\alpha(B^2) < 0$ [cf equation (5)], while the MOCB experimental result $b^{exp} > 0$ relates to $\alpha(B^2) > 0$. The latter holds for the effect of multipolar optical polarizability transitions in the biomolecule, this being a carrier of the unneoplasmic status governed by the positive value of b^{exp}. For enantiomers the absolute values of $b^{(+)}$ and $b^{(-)}$ are the same, which is also same for absolute values of α^+ and α^- [2]. For serum, the experimental results indicate that, irrespective of the health status of the patients, their effective natural optical activity $\alpha = \alpha^+ + \alpha^-$ is dextorotatory (tables 2 and 3). The experimental results of the study and the parameters calculated from these data are given in tables 1–4.

3. Results

On the basis of the statistical analysis of the correlation between the magnetooptical data, $b^{exp} < 0$ and/or $b^{exp} > 0$, and the clinical diagnosis of patients, it was possible to select a range of the $b^{exp} < 0$ corresponding to a positive predictive value (PPV) of the screening tests for a characteristic disease.

The possibility of differentiation between the cancer and inflammation states on the basis of the magnetooptical results has been tested for patients with prostate cancer and separately for those with prostate inflammation.

The PPV presented for prostate inflammation in table 1 concerns the clinical diagnosis and the MOCB results for patients with $b^{exp} > 0$. Analysis of a reasonable number of patients with a given disease permits us to infer a statistically reliable correlation between the type of neoplasmic changes and the value of the magnetooptical data determined from the blood serum samples. The MOCB sample results (table 2) concern the patients with ovarian cancer, mammae cancer and prostate cancer, in contrast to those with prostate inflammation and healthy blood donors (table 3) as non-cancer cases.

4. Neoplasmic changes information carrier

The MOCB data collected [1,4–7] suggest that the blood serum of cancer patients contains [8] a stable biomolecular structure generated by the disease [10]. Similar opinions have been presented in some works on ovarian cancer [11], prostate cancer [12–14] and many remarks are given in [15] on the detection of early prostate cancer.

The magnetooptical $\alpha(B^2)$ effect induced in the blood serum of cancer patients can be described as the biomolecular response to the second power B^2 magnetic field interaction with molecules. The present study suggests that the B^2 effect in serum can be analysed (equation (5)) as the magnetic field induced rotation $\alpha(B^2)$. Human serum is an

Table 2. Magnetooptical characteristics of clinically diagnosed different patients. Quadratic magnetic field induced circular birefringence parameter $b^{exp} < 0$, effective natural optical activity α, assigned neoplasmic change Q, density number ${}^{(-)}\rho$ and ${}^{(+)}\rho$ of the magnetooptical active carriers in patient's serum.

	$b^{exp} < 0$ (deg T^{-2} mm^{-1})	α (deg mm^{-1})	Q (deg^{-1} T^2 mm)	ρ (mol mm^{-3})		Age
n	$10^5 b^{exp}$	$10^3 \alpha$	$10^{-3} Q$	$10^{-18}\,{}^{(-)}\rho$	$10^{-18}\,{}^{(+)}\rho$	(years)
Ovarian cancer						
1	−31.5	89.21	−3.17	4.01	2.84	51
2	−27.8	48.80	−5.82	3.54	1.55	51
3	−22.5	49.30	−5.73	2.86	1.57	67
4	−20.8	34.03	−8.30	2.64	1.08	44
5	−16.8	87.66	−3.29	2.14	2.79	54
6	−16.5	38.68	−7.30	2.10	1.23	59
7	−9.8	49.15	−5.75	1.24	1.56	51
8	−7.9	47.85	−5.90	1.00	1.52	41
9	−7.8	76.88	−3.68	0.99	2.44	17
10	−6.9	48.10	−5.84	0.87	1.53	53
11	−5.6	88.02	−3.21	0.71	2.80	55
12	−3.6	38.96	−7.25	0.46	1.24	57
13	−3.6	58.62	−4.81	0.45	1.86	72
14	−1.2	70.27	−4.02	0.15	2.23	37
15	−0.3	47.85	−5.90	0.04	1.52	62
16	−0.2	67.13	−4.21	0.02	2.13	53
		$Q_q = -5.3 \times 10^3$ deg^{-1} T^2 mm				
Mammae cancer						
1	−69.0	54.0	−1.44	8.78	1.71	
2	−56.0	65.0	−1.20	7.13	2.07	
3	−33.0	54.0	−1.44	4.12	1.71	
4	−30.0	58.0	−1.34	3.82	1.84	
5	−24.0	58.0	−1.34	3.05	1.84	
6	−19.7	78.0	−1.03	2.50	2.48	
7	−18.0	65.0	−1.20	2.29	2.07	
8	−16.3	62.0	−1.26	2.07	1.97	
9	−15.0	65.0	−1.20	1.91	2.07	
10	−3.6	63.8	−1.22	0.46	2.03	
		$Q_q = -1.2 \times 10^3$ deg^{-1} T^2 mm				*t*PSA
Prostate cancer						
1	−42.3	75.16	−2.36	5.38	2.39	4.54
2	−26.4	54.80	−3.24	3.36	1.74	5.98
3	−20.0	74.40	−2.38	2.54	2.36	4.02
4	−15.4	57.40	−3.09	1.95	1.82	6.09
5	−9.5	44.73	−3.97	1.20	1.42	5.14
6	−7.4	74.41	−2.38	0.94	2.36	4.02
7	−6.4	28.08	−6.32	0.81	0.89	2.86
8	−5.9	38.60	−4.60	0.75	1.22	5.45
9	−2.8	49.30	−3.60	0.35	1.57	13.80
10	−2.2	39.68	−4.47	0.28	1.26	18.81
11	−1.4	29.40	−6.04	0.18	0.93	6.70
		$Q_q = -3.8 \times 10^3$ deg^{-1} T^2 mm.				

${}^{(-)}\rho_1 = {}_1bB^2L/(-10^{-20})/15.7$ deg mm^{-3}, ${}^{(-)}\rho_n = {}^{(-)}\rho_1\{{}_nb/{}_1b\}$, $B = 20$ T, $L = 5$mm,
${}^{(+)}\rho_n = 5({}_n\alpha)/10^{-20}/15.7$ deg mm^{-3}, $V_{eff} = 15.7$ mm^3, tPSA prostate cancer marker (ng mL^{-1}).

isotropic chiral medium and their quadratic magnetic field induced circular birefringence is observed [1–7].

The physical interpretation of the MOCB effect observed in human blood serum is considered from the result of [9] given for the specific molecular Y, K diamagnetic point group symmetries (globular) of isotropic chiral media.

Table 3. Magnetooptical characteristics of clinically diagnosed different patients. Quadratic magnetic field-induced circular birefringence parameter $b^{\exp} > 0$, effective natural optical activity α, assigned neoplasmic change Q, density number ${}^{(+)}\rho_{\mathrm{M}}$ and ${}^{(+)}\rho$ of the magnetooptical active carriers in patient's serum.

n	$10^5\, b^{\exp}$	$10^3\,\alpha$	$10^{-3}\,Q$	$10^{-18(+)}\rho_{\mathrm{Mn}}$	$10^{-18(+)}\rho_n$	tPSA
Prostate inflammation						
1	35.5	96.99	2.81	4.52	3.08	$<5\,\mathrm{ng\,mL^{-1}}$
2	34.1	59.40	4.59	4.34	1.89	
3	19.7	52.13	5.23	2.50	1.66	
4	16.7	54.98	4.96	2.12	1.75	
5	14.1	31.39	8.69	1.79	0.99	
6	7.2	58.92	4.63	0.91	1.87	
7	6.6	72.73	3.75	0.84	2.31	
8	4.3	75.81	3.60	0.54	2.41	
9	1.2	64.76	4.21	0.15	2.06	
			$Q_{\mathrm{q}} = 4.7 \times 10^3\,\mathrm{deg^{-1}\,T^2\,mm}$			

${}^{(+)}\rho_{\mathrm{M1}} = {}_1bB^2L/(10^{-20})/15.7\,\mathrm{deg\,mm^{-3}}$, ${}^{(+)}\rho_{\mathrm{Mn}} = {}^{(+)}\rho_{\mathrm{M1}}\{{}_nb/{}_1b\}$, $B = 20\,\mathrm{T}$, $L = 5\,\mathrm{mm}$, ${}^{(+)}\rho_n = 5({}_n\alpha)/10^{-20}/15.7\,\mathrm{deg\,mm^{-3}}$, $V_{\mathrm{eff}} = 15.7\,\mathrm{mm^3}$, $\mathrm{tPSA} < 5\,\mathrm{ng\,mL^{-1}}$.

Healthy blood donors [4]						Rh/group
1	38.0	64	2.63	4.84	2.03	0/−
2	30.0	49	3.43	3.82	1.55	B/−
3	20.0	62	2.71	2.54	1.97	0/−
4	19.0	57	2.95	2.42	1.81	A1/+
5	16.4	75	2.24	2.08	2.32	B/+
6	6.4	58	2.90	0.81	1.84	0/+
7	5.0	66	2.55	0.63	2.10	A1/+
8	2.4	64	2.63	0.30	2.03	B/−
9	2.0	62	2.71	0.25	1.97	A/−
10	1.6	56	3.00	0.20	1.78	0/+
			$Q_{\mathrm{q}} = 2.7 \times 10^3\,\mathrm{deg^{-1}\,T^2\,mm}$			

${}^{(+)}\rho_{\mathrm{M1}} = {}_1bB^2L/(10^{-20})/15.7\,\mathrm{deg\,mm^{-3}}$, ${}^{(+)}\rho_{\mathrm{Mn}} = {}^{(+)}\rho_{\mathrm{M1}}\{{}_nb/{}_1b\}$, $B = 20\,\mathrm{T}$, $L = 5\,\mathrm{mm}$, ${}^{(+)}\rho_n = 5({}_n\alpha)/10^{-20}/15.7\,\mathrm{deg\,mm^{-3}}$, $V_{\mathrm{eff}} = 15.7\,\mathrm{mm^3}$, Rh group.

Table 4. The Q value (in $10^3\,\mathrm{deg^{-1}\,T^2\,mm}$) assigned to particular type of neoplasmic changes.[a]

Ovarian cancer	Prostate cancer	Mammae cancer
−5.2	−3.8	−1.2
Prostate inflammation	Healthy blood serum	Rheumatic inflammation
4.7	2.7	0.7

[a] $Q < 0$: ovarian, prostate and mammae cancer and of non-neoplasmic cases. $Q > 0$: prostate inflammation, healthy blood. serum, rheumatic inflammation.

The dextrorotatory (α^+, $b^{\exp} > 0$) and laevorotatory (α^-, $b^{\exp} < 0$) molecules subjected to a magnetic field B and an optical field $\mathbf{k}$ rotate the polarization plane of the light passing through a chiral medium by $\alpha(B^2)\,\mathrm{deg}$. The $\alpha(B^2)$ effect (equation (5)) is described by the g_{e5} and g_{m5} molecular polarizabilities tensors related to the electric quadrupole and magnetic dipole transitions, respectively. From [9] we get the following expression:

$$\alpha(B^2)/B^2L = (2\pi/\lambda)(-g_{\mathrm{e5}} + g_{\mathrm{m5}}) \tag{6}$$

and from equation (5) we get

$$\alpha(B^2)/B^2L = b^{(-)} + b^{(+)}. \tag{7}$$

So, from equations (6) and (7):

$$(2\pi/\lambda)(-g_e 5 + g_{m5}) = b^{(-)} + b^{(+)}. \tag{8}$$

The blood serum biomolecules carrying the information on the neoplasmic changes $b^{(-)} < 0$, in a strong magnetic field **B** and the optical field **k**, generate quadrupolar electric transitions following from the multipolar optical polarizability of the ${}^{(-)}\rho$ laevorotatory carriers and the dipolar magnetic transitions of the ${}^{(+)}\rho$ dextrorotatory carriers. Quadrupolar electric transitions determine the MOCB effect: $\alpha(B^2) = b^{(-)}B^2L$, while the dipolar magnetic ones the effect: $\alpha(B^2) = b^{(+)}B^2L$. From [9] we get the following expressions for g_{e5} and g_{m5}:

$$g_{e5} = {}^{(-)}\rho(2\omega/3)(\mu_0/\varepsilon_0)^{1/2}\, {}^{(1)}_{e}\beta^{(2)mm}_{e(12)(13)}, \tag{9}$$

$$g_{m5} = {}^{(+)}\rho(\mu_o/\varepsilon_o)^{1/2}\, {}^{(1)}_{e}\gamma^{(1)mm}_{m11(22)}, \tag{10}$$

where ${}^{(-)}\rho$ is the number of the laevorotatory molecules of the medium/matrix taking part in the $b^{(-)}B^2L$ effect, and ${}^{(+)}\rho$ is the number of dextrorotatory molecules in the medium/matrix taking part in the $b^{(+)}B^2L$ effect.

Also, from equation (8):

$$b^{(-)} = {}^{(-)}\rho G\lambda^{-2}\, {}^{(1)}_{e}\beta^{(2)mm}_{e(12)(13)} \quad \text{and} \quad b^{(+)} = {}^{(+)}\rho K\lambda^{-1}\, {}^{(1)}_{e}\gamma^{(1)mm}_{m11(22)} \tag{11}$$

where: $G = (8\pi^2 c/3)(\mu_o/\varepsilon_o)^{1/2} = 9.7946 \times 10^{15}\,\mathrm{deg^2\,J\,A^{-2}\,m\,s^{-2}}$, $c = 3 \times 10^8\,\mathrm{m\,s^{-1}}$ and $K = 2\pi(\mu_o/\varepsilon_o)^{1/2} = 1.3603 \times 10^5\,\mathrm{deg\,J\,A^{-2}\,s^{-1}}$. For a non-chiral medium: ${}^{(-)}\rho = 0$ and ${}^{(+)}\rho = 0$ and from equations (9) and (10): $g_{e5} = g_{m5} = 0$ and from equations (7) and (8); $\alpha(B^2) = 0$.

Therefore, for ${}^{(+)}\rho \neq 0$,

$$\alpha(B^2)/B^2L = (2\pi/\lambda)g_{m5}, \tag{12}$$

while for ${}^{(-)}\rho \neq 0$:

$$\alpha(B^2)/B^2L = (2\pi/\lambda)g_{e5}. \tag{13}$$

and the total $\alpha(B^2)$ effect, induced by the ${}^{(-)}\rho \neq 0$ and ${}^{(+)}\rho \neq 0$ carriers in the serum sample is described (equation (11)) by the relation:

$$b^{(-)} + b^{(+)} = -{}^{(-)}\rho G\lambda^{-2}S_q + {}^{(+)}\rho K\lambda^{-1}R_q \tag{14}$$

where S_q and R_q, respectively, denote the tensors: ${}^{(1)}_{e}\beta^{(2)mm}_{e(12)(13)}$ and ${}^{(1)}_{e}\gamma^{(1)mm}_{m11(22)}$, the electric quadrupolar and the magnetic dipolar transition representations and contribution to the effective experimental value of $b^{exp} = b^{(-)} + b^{(+)}$.

Equation (14) permits an interpretation of the physics of the magnetooptical effect observed in the serum from cancer patients and/or non-cancer cases. The magnetooptical parameter characteristic of neoplasmic changes is $b^{exp} < 0$, while for non-neoplasmic cases b^{exp} is positive. Equation (14) is fulfilled by assuming $b^{(-)} = -{}^{(-)}\rho G\lambda^{-2}S_q$ and $b^{(+)} = {}^{(+)}\rho K\lambda^{-1}R_q$, where $G\lambda^{-2} = 4.114 \times 10^{28}$,

$K\lambda^{-1} = 2.786 \times 10^{11}$ ($\lambda = 488 \times 10^{-9}$ m). So, the numerical result (equation (14)) is: $b^{(-)} + b^{(+)} = -4.114 \times 10^{28(-)}\rho S_q + 2.786 \times 10^{11(+)}\rho R_q$.

For an experimental result $b^{exp} < 0$ the quadrupolar-electric contribution ($-4.114 \times 10^{28(-)}\rho S_q$) describes the effect of the neoplasmic changes while for serum of non-neoplasmic case the dipolar magnetic ($2.786 \times 10^{11(+)}\rho R_q$) contribution holds for the experimental result of $b^{exp} > 0$. This statement seems to be acceptable as for $b^{exp} = 0$, the overall contribution of the MOCB effect in serum (equation (7)); $b^{(+)} + b^{(-)} = 0$, implies that any case of $b^{exp} < 0$, compared to the equivalent state:

$$-4.114 \times 10^{28(-)}\rho S_q + 2.786 \times 10^{11(+)}\rho R_q = 0 \tag{15}$$

is a result of increasing $b^{(-)}$ and decreasing the density number ${}^{(-)}\rho$ in a serum (see tables 2 and 3). For example, for a result of $b^{exp} > 0$ and/or of $b^{exp} < 0$, quantitative calculations on the basis of equation (14) give: $b^{(-)} = -42.37 \times 10^{-2}\,\mathrm{deg\,T^{-2}\,m^{-1}}$ for ${}^{(-)}\rho = 1.03 \times 10^{27}\,\mathrm{mol\,mm^{-3}}$ and $S(q) = 10^{-56}$, while $b^{exp} = -42.3 \times 10^{-2}\,\mathrm{deg\,T^{-2}\,m^{-1}}$ (cf table 2, $n = 1$, prostate cancer).

For the case of prostate inflammation: $b^{(+)} = 35.38 \times 10^{-2}\,\mathrm{deg\,T^{-2}\,m^{-1}}$ for ${}^{(+)}\rho = 12.7 \times 10^{30}\,\mathrm{mol\,mm^{-3}}$ and $R(q) = 10^{-43}$, while $b^{exp} = 35.5 \times 10^{-2}\,\mathrm{deg\,T^{-2}\,m^{-1}}$ (table 3, $n = 1$). The correlation between the values of b^{exp} and the calculated $b^{(+)}$ and/or $b^{(-)}$ is reasonable.

So, the physical information carried by the ${}^{(-)}\rho$ carrier, which has not been identified yet, is consistent with the analytical form of equation (14).

For human blood serum, the laevorotatory carriers with natural optical activity effect α^- is effectively compensated by the natural optical activity α^+ of the dextrorotatory carriers and the result of the serum natural optical activity $\alpha^+ \gg \alpha^-$. The natural optical activity of serum samples is positive and $\alpha^{exp} = \alpha L$ (tables 2 and 3) is of the order of 10^{-3} deg ($L = 5$ mm). For an optical effective volume $V_{eff} = 15.7\,\mathrm{mm^3}$ of the serum sample a typical result (table 3, $n = 1$) is: $\alpha^{exp} = 0.48$ deg and the value of ${}^{(+)}\rho_1$ calculated on the basis of the natural optical activity of the exemplary serum is: ${}^{(+)}\rho_1 = 3.14 \times 10^{18}\,\mathrm{mol\,mm^{-3}}$ where ${}^{(+)}\rho_1 = 0.48/15.7/{}^{p.m.}\alpha_0$ and ${}^{p.m.}\alpha_o = 10^{-20}\,\mathrm{deg\,mol^{-1}}$ is chosen from [3] as a normalized value. The ${}^{(+)}\rho_1 = 3.14 \times 10^{18}\,\mathrm{mol\,mm^{-3}}$ is the calculated density number of dextrorotatory carriers in the serum sample from a patient with prostate inflammation while calculated on the MOCB data result: ${}^{(+)}\rho_{M1} = {}_1bB^2L/(10^{-20})/15.7\,\mathrm{deg\,mm^{-3}} = 4.52 \times 10^{18}\,\mathrm{mol\,mm^{-3}}$ is the density number of the dextrorotatory carriers effective in $\alpha(B^2)$ excitation ($B = 20$ T, ${}_1b = 35.5 \times 10^{-5}\,\mathrm{deg\,T^{-2}\,mm^{-1}}$). For blood serum the parameters ${}^{(-)}\rho G\lambda^{-2}S_q$ and ${}^{(+)}\rho)K\lambda^{-1}R_q$ are responsible (equation (14)) for the result of $b^{(-)}$ and $b^{(+)}$, respectively. The neoplasmic status ($b^{exp} < 0$) can be detected by the MOCB technique even for ${}^{(-)}\rho \ll {}^{(+)}\rho$ as $G\lambda^{-2} = 4.114 \times 10^{28}$ while $K\lambda^{-1} = 2.786 \times 10^{11}$.

The MOCB effect directly yields the ratio ${}^{(-)}\rho_n/{}^{(-)}\rho_1$ for a series experimental data of ${}_nb/{}_1b$ for different patients. The results (equations (5) and (14)) are:

$${}^{(-)}\rho_n/{}^{(-)}\rho_1 = \left({}_nb^{(-)}/{}_1b^{(-)}\right)S_1(q)/S_n(q) \tag{16}$$

and for $S_1(q) = S_2(q) = S_n(q)$ equation (16) yields:

$${}^{(-)}\rho_n/{}^{(-)}\rho_1 = {}_n\,b^{(-)}/{}_1b^{(-)}, \tag{17}$$

the ${}^{(-)}\rho_n/{}^{(-)}\rho_1$ ratio expressed by ${}_nb^{(-)}$ and ${}_1b^{(-)}$ MOCB experimental data. The results of the ${}^{(-)}\rho_n = {}^{(-)}\rho_{M1}\{{}_nb^{(-)}/{}_1b^{(-)}\}$ calculation are given in table 2, and in table 3

for ${}^{(+)}\rho_n$ and ${}^{(+)}\rho_{M1}$ of prostate inflammation and healthy blood donors serum. Exact values of ${}^{(-)}\rho_l$ and ${}^{(-)}\rho_n$ densities of laevorotatory carriers in the neoplasmic serum can be obtained from the experimental data S_n and ${}^{(-)}\rho_l$ of q-serum and/or for neat enantiomers (e.g., for the 85% lactic acid laevorotatory enantiomer: ${}^{(-)}\rho = 1.14 \times 10^{18}\,\mathrm{mm}^{-3}$ [3]).

Let us introduce the following relation:

$$Q_q = (1/N)\sum_{n=1}^{N} Q_n \tag{18}$$

where $Q_n = ({}_l\alpha/{}_lb)/{}_n\alpha$.

Results of Q_q calculations for the serum samples from the patients with ovarian cancer, mammae cancer and prostate cancer are given in table 2 (patients clinically diagnosed, neoplasmic cases), prostate inflammation and healthy blood donors (table 3 non-neoplasmic cases, also clinically diagnosed). It should be pointed out that magnetooptical Q_q results for the neoplasmic cases permit a classification of different neoplasmic changes according to the value of Q_q. The present results of the MOCB examination of some neoplasmic changes and their specific Q_q values are given in table 4. The result $Q_q < 0$ suggests the occurrence of neoplasmic changes information carriers in human blood serum detectable by MOCB effect and $Q_q > 0$ relate to a non-neoplasmic case.

5. Conclusions

The MOCB data suggest that the blood serum of cancer patients contains a stable biomolecular structure generated by the disease and carrying the information on the health status of the patient. The number of these biomolecules determines the intensity of the MOCB signal.

This article presents a quantitative correlation between the experimental values of ${}_nb$ and ${}_n\alpha$ and the presence of neoplasmic changes q. The Q_q parameter distinguishes different disease status of patients.

The main source of information on the neoplasmic disease is the quadrupolar electric transitions of biomolecules in the serum of the patient with a neoplasmic condition. In the samples of blood serum of healthy patients or those after successful therapy, b^{exp} assumes positive values [6]. The appearance of metastasis is again signaled by the negative values of the magnetooptical b^{exp} result.

In the blood serum samples of the patients with the prostate inflammation and rheumatic inflammation state, the magnetooptical b^{exp} characteristic is positive ($b^{exp} > 0$). Besides providing the values of b^{exp} the magnetooptical measurements of blood serum also permit determination of the Verdet constants characterizing the linear (a) and non-linear (c) Faraday effect. However, these effects do not provide relevant information for the analysis of the presence and development of a neoplasmic disease. The negative value of the b^{exp} measured for blood serum indicating the presence of neoplasmic changes is not claimed to correspond only to neoplasmic diseases, it only reports that such a relationship has been found for the examples studied. The results of the study do not exclude that a negative value of b^{exp} would indicate some other diseases.

Acknowledgements

The author is grateful to the following medical centers and their respective representatives for the cooperation in providing the samples necessary for the study:

(1) The Gynaecological Oncology Clinic of the Medical University, Poznań, Poland M. Spaczyński, M.D., Ph.D., M. Michalak, M.D.
(2) Chair and Clinic of Orthopaedics, Poznań P. Rogala, M.D.
(3) The Greater Poland Oncology Centre, Poznań G. Bąk, M.D.
(4) Chair of the Chemistry and Biochemistry Laboratory, Medical University, Poznań A. Wierzbicki, Ph.D., M. Ociepa, M.D.
(5) Clinical Laboratory, Hospital of Gniezno, Poland E. Raczkowska, M.Sc., A. Rafalont, M.Sc.
(6) The Central Blood Donor Laboratory, Poznań J. Bućko, M.D.

References

[1] M. Surma. *Molec. Phys*., **90**, 993 (1997).
[2] M. Surma. *Molec. Phys*., **93**, 271 (1998).
[3] M. Surma. *Molec. Phys*., **96**, 429 (1999).
[4] M. Surma, J. Bućko, G. Bąk, M. Ciszek. *Acta Phys. Polon., A*, **98**, 533 (2000).
[5] A. Mikusińska-Planner, M. Surma. *Spectrochim. Acta, Part A*, **56**, 1835 (2000).
[6] M. Surma, J. Bućko, G. Bąk, M. Ciszek. *Polish J. Med., Phys & Eng*., **7**(1), 25 (2003).
[7] J. Gągalska. Rentgenowskie bandania surowicy krwi ludzkiej fizjologicznie i patologicznie zmienionej, PhD thesis, A. Mickiewicz University, Department of Physics (2004).
[8] A. Mikusińska-Planner, J. Gągalska, M. Pochylski, M.M. Kaczmarek. *Phys. Chem. Liq*., **43**(2), 167 (2005).
[9] R. Zawodny, S. Woźniak, G. Wagnière. *Molec. Phys*., **91**, 165 (1997).
[10] M. Surma. BioMicroWorld 2005, *International Conference, Poster Code117*, Badajoz, Spain 2005; March 15–18. http://www.formatex.org/biomicroworld2005/result.php (2005).
[11] M.M. Hussain, H. Kotz, L. Minasian, Ahalya Premkumar, Gisele Sarosy, Eddie Reed, Suoping Zhai, Seth M. Steinberg, Miranda Raggio, Vyta Culpa Oliver, William D. Figg, Elise C. Kohn. *Journal of Clinical Oncology*, **21**(23), 4356 (December 2003).
[12] R.C. Smith, M. Litwin, Y. Lu, B.R. Zetter. *Medicine*, **1**, 1040 (1995).
[13] C. Koike, D.T. Chau, B.R. Zetter. *Cancer Res*., **59**, 6109 (1995).
[14] L. Boa, M. Loda, P.A. Janmey, B. Anand-Apte, B.R. Zetter. *Nature Medicine*, **2**, 1322 (1996).
[15] C. Mettlin, F. Lee, J. Drago, G.P. Murphy. *Cancer*, **67**, 2949 (1991).