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(54) **TOTAL HEMOGLOBIN CONCENTRATION MEASUREMENT**

MESSUNG DER GESAMTKONZENTRATION VON HÄMOGLOBIN

MESURE DE LA CONCENTRATION TOTALE DE L'HEMOGLOBINE

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Description

BACKGROUND OF THE INVENTION

[0001] Spectrophotometric instruments and methods for measuring the amount of a tissue chromophore having a certain functional state (e. g., the percentage of oxidized hemoglobin or St02, and the percentage of oxidized cytochrome aa3) are generally known and disclosed, for example, in the Anderson et al. U. S. Patent 5,879,294. The Anderson et al. patent discloses in particular a measurement algorithm which makes use of scaled second derivative spectrum values.

[0002] The Kuestner U. S. Patent 5,377,674 discloses a spectrophotometric instrument and method for measuring the total concentration of a chromophore such as hemoglobin in tissue. The measurement algorithm uses a single term ratio of second derivative absorbance measured at a wavelength at which hemoglobin absorption occurs (analyte wavelength), and a second derivative absorbance measured in a wavelength region where no hemoglobin absorption occurs (reference wavelength) (e. g, 2nd derivative of absorbance at 1740 nm/2nd derivative of absorbance at 1346 nm).

[0003] The Osten et al. U.S. Patent 5,729,333 discloses a method for predicting a property of a biological fluid where the fluid may be approximated to contain two compartments where one compartment has a proportionally larger or smaller amount of water than the other compartment having the property of interest. A training set in the near-infrared (NIR) region is established with independent quantification of the property using known techniques. The training set is analyzed according to a correlation developed by regression analysis after use of a pre-processing technique such as a multiple derivative transformation of spectra or rationing of two wavelengths in the spectra.

[0004] The Anderson application, EP 0816829 discloses a method and device for determining concentrations for a predetermined tissue chromophore with respect to the total concentration a different, but related tissue chromophore within a predetermined tissue of interest. To accomplish this, an absorbance spectrum is established at many different wavelengths. The absorbance spectrum is transformed into a second derivative spectrum which is subsequently scaled. This leads to a spectrum which is robust to changes in amplitude and constant slope bias as well as to changes in optical pathlength and total chromophore concentration. Selected spectra of the second derivative spectrum are manipulated within a neural network to generate quantified output data values representative of actual concentrations of the predetermined tissue chromophore with respect to the total concentration of the different, but related chromophore.

[0005] There remains, however, a continuing need for improved instruments and methods for measuring the total concentration of chromophores such as hemoglobin in tissue.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

Figure I is a graph of an example of measured bovine blood second derivative absorbance values as a function of wavelength at a range of conditions of oxyhemoglobin optical density.

Figure 2 is a graph of an example of measured bovine blood second derivative absorbance value data points as a function of hemoglobin oxidation state at hematocrit levels of 47%, 25% and 15%.

Figure 3 is a graph of lines fitted to the data points shown in Figure 2.

Figure 4 is a graph of bovine blood second derivative absorbance values as a function of hematocrit concentrations derived from the data shown in Figure 3 at hemoglobin oxidation (i. e., functional) states of 0%, 25%, 50%, 75% and 99%.

Figure 5 is an example of a lookup table of data derived from the data shown in Figure 4 and describing the relationship between hemoglobin oxidation state and hematocrit levels.

Figure 6 is a graph of data showing the correlation between hematocrit measurements made using the described invention and a reference method by which a centrifuged Wintrobe tube is used to measure the height of packed red blood cells relative to the total sample height (red blood cells and plasma).

Figure 7 is a graph of test data showing the correlation between hematocrit measurements made using the described invention in which hemoglobin oxidation state was varied while hematocrit levels remain constant.

Figure 8 is a graph of an example of measured second derivative absorbance value data points as a function of wavelength at probe send-to-receive fiber spacings of 5 mm, 10 mm, 15 mm and 20 mm.

Figure 9 is a graph of an example of probe scaling factors (PSF) as a function of probe spacing derived from the data shown in Figure 8 and referenced to a spacing of 5 mm.

SUMMARY OF THE INVENTION

[0007] A method for measuring the total concentration of a chromophore, such as hemoglobin, in tissue. The method

includes providing stored relationship data characterizing the relationship between second derivative absorbance values at a chromophore-absorbing wavelength and the concentration of the chromophore in the tissue. Data representative of a measured second derivative absorbance value from tissue being analyzed is received. Data representative of the chromophore concentration can then be generated as a function of the second derivative absorbance value and the stored relationship data. In one embodiment of the invention, the measured chromophore concentration can be used to evaluate the accuracy of measurements of a functional state of the chromophore (e.g., the oxygenation state of the hemoglobin).

DETAILED DESCRIPTION OF THE INVENTION

[0008] The invention is an instrument and method for using the combination of both a single term ratio of a second derivative absorbance value and a single term non-ratioed second derivative value to measure the volume percentage of a chromophore such as hemoglobin in tissue (a value that directly correlates with hemoglobin concentration). The wavelengths used by the method are all within a region where hemoglobin absorption takes place. There is no requirement for a "reference wavelength" which occurs in a region where hemoglobin absorption does not take place. An advantage of the invention is that the spectral region from 680 nm to 800 nm can be used to measure hemoglobin concentration. In this wavelength region the oxygenation state of hemoglobin (%StO2) (i.e., a portion of the chromophore having a particular functional state) is a factor which must be considered when making total hemoglobin concentration measurements using derivative spectroscopy. The utilization of both a single term derivative ratio (which varies with %StO2) and a non-ratioed second derivative term (which varies with %St02 and total hemoglobin concentration) provides a means to distinguish hemoglobin concentration separately from the amount of oxidized hemoglobin. The non-ratioed second derivative term (at 720 nm in the embodiment described herein) is also used in the denominator of the ratioed second derivative term. Both hemoglobin oxidation percentage and total hemoglobin concentration percentage can be obtained with a minimum of wavelength specific absorbance measurements (e.g., 4 wavelengths are used in the instrument disclosed in the Anderson et al. patent).

[0009] In one configuration the wavelength gap used to calculate the second derivative values (i.e., the interval between adjacent absorbance wavelengths used in the second derivative calculation) is 40 nm. At this gap size only four wavelengths are used to calculate both the percentage of oxidized hemoglobin and the percentage of total hemoglobin in the tissue (% hematocrit). The second derivative absorbance peak at 720 nm (deoxyhemoglobin absorption band of 760 nm) is used to empirically derive the relationship between percent hematocrit and second derivative absorbance. Second derivative gap sizes other than 40 nm can also be used to derive the hematocrit algorithm. Also, other wavelength regions (e.g., visible or infrared) corresponding to other oxyhemoglobin or deoxyhemoglobin absorbance maximums could be used.

[0010] The total hemoglobin concentration measurements made in accordance with the algorithms described herein can be used by an instrument in connection with tissue recognition algorithms. Inaccurate and/or invalid measurements of %St02 or other measured parameters can be displayed by the instrument monitor if the probe is not properly located on the tissue to be measured. The total hemoglobin concentration measurement can be used by the instrument to determine whether the probe is properly positioned and the measurement is accurate. For example, in connection with some or all of the parameter measurements, the instrument can compute the total hemoglobin concentration using the algorithm described herein, and display the parameter measurement as an accurate measurement only if the hemoglobin concentration measurement is representative of a predetermined minimum level. If the hemoglobin concentration measurement is below the predetermined level, the monitor can generate a display indicating that the probe is not properly positioned.

[0011] Total hemoglobin concentration measurements in accordance with the invention can be generated as a function of current second derivative spectroscopy values and stored data describing the relationship between the second derivative values and the total hemoglobin concentration. In the embodiment described below, the stored relationship data is data describing a set of lines or slopes (or curves if preferred), each of which is associated with a constant oxidation state of hemoglobin.

[0012] During total hemoglobin concentration measurements, the proper stored relationship data can be selected by the instrument on the basis of the measured hemoglobin oxidation state. From this data and the current second derivative spectroscopy value, the total hemoglobin concentration can be computed-by the instrument.

[0013] Stored second derivative/hemoglobin concentration relationship data can be generated in the following manner. Figure 1 is a graph of measured second derivative (40 nm gap) spectra of bovine blood at a range of conditions of oxyhemoglobin optical density. The shape transformation of the illustrated spectra (e.g., peak height at 720 nm) is influenced by three primary factors (%StO2, % hematocrit and optical path length). The height of the second derivative absorbance values shown in Figure 1 varies directly with hemoglobin concentration and inversely with the hemoglobin oxidation state. To determine the % hematocrit from unscaled second derivative features, both the %St02 and path length need to be defined.

[0014] At multiple levels of hematocrit (HCT), the second derivative spectral features of the blood are recorded at a predetermined (e.g., 5 mm) probe spacing over multiple % St02 values within the 0%-100% range as illustrated in Figure 2. For each hematocrit the 720 nm second derivative peak is fitted to a linear equation as is illustrated in Figure 3.

[0015] At each constant level of %StO2, the second derivative 720 nm feature is related to % hematocrit with extrapolation to 0% hematocrit. As illustrated in Figure 4, from this step it is evident that there is a linear relationship between the 720 nm second derivative and hematocrit at hematocrits of about 25% and less.

[0016] Using linear extrapolation to 0% hematocrit and empirical measurements at 25% and 15% hematocrit, a lookup table of relationship data which describes the sensitivity of hematocrit to the 720 nm second derivative values (lines of constant %StO2) can be created as illustrated in Figure 5. The slopes are functionally related to the ratio of the second derivative at 680 nm to the second derivative at 720 nm. Figures 6 and 7 are graphs of several verification exercises (tests) performed for the algorithm described above.

[0017] To compensate for measurements made with probe spacings other than that used to generate the relationship data, a probe scaling factor (PSF) which relates the relative change in path length due to probe spacing is used to adjust the 720 nm second derivative values.

[0018] The stored relationship data described above is subsequently used during total hemoglobin concentration measurements. Upon measuring %St02 (e.g., using conventional algorithms and scaled second derivative values at 680 nm) the corresponding slope value (Mso2 or hct slope) is found within the lookup table. The predicted hematocrit value is then:

$$\%Hct = Mso2 \times D720 / PSF$$

Where: D720 is the second derivative at 720 nm using the 40 nm gap
PSF is the relative path length change due to probe spacing

[0019] The concentration of tissue hematocrit is generally less than 25%, and is usually in the 1%-10% range. When evaluating probe position on the basis of hemoglobin concentration measurements, relatively high measurement accuracy near the lower end of the range is sufficient. For example, the threshold for determining whether the probe is on or off tissue can be in the range of 1% measured hemoglobin concentration. The linear range of spectral features versus hematocrit concentration (e.g., less than about 25% in Figure 4) need only be used for this application. However, in accordance with the present invention, the measurement accuracy can be extended to greater percentages of hematocrit by redefining the algorithm to account for nonlinearities. The algorithm could, for example, be redefined as a multiple regression algorithm consisting of multiple slope and second derivative transformations (linear transformations). Examples of nonlinear equations include:

$$\%Hct = Mso2_1 \times (D720/PSF) + Mso2_2 \times Log(D720/PSF)$$

or

$$\%Hct = Mso2_1 \times (D720/PSF) + Mso2_2 \times (D720/PSF)^{½} + Mso2_3 \times (D720/PSF)^{1/3} + ...$$

Where: $Mso2_1$, $Mso2_2$, ... are nonlinear slope value coefficients which can be stored in the lookup table.

[0020] The probe scaling factor (PSF) can be empirically determined by collecting second derivative spectral measurements of a chromophore medium, preferably having constant scattering and absorption properties, with optical probes having variable distances between the optical send and receive fibers. The spectral measurements at each probe spacing are then referenced (ratioed) to one of the fixed probe spacing spectral measurements at a particular wavelength of interest. The ratio of one second derivative spectrum value at a probe spacing of interest to the second derivative spectrum value of the reference probe spacing then reflects the probe scaling factor. Figure 8 is a graph of second derivative spectra measured at 4 different probe spacings. The medium used to obtain the data in Figure 8 was a 2.5% aqueous solution of 1 micron polystyrene microspheres. Figure 9 represents the probe scaling factor measured from the ratio of second derivative spectrum values at approximately 725 nm (the absorbance peak in Figure 8). The following equation represents an example calculation of the probe scaling factor from the spectral information in Figure 9:

$$\text{PSF (20 mm probe)} = \frac{\text{725nm } 2^{nd} \text{ derivative value (20 mm probe)}}{\text{725 nm 2nd derivative value (5 mm probe)}}$$

[0021] The denominator in the equation represents the reference probe spacing (the probe spacing used to create the hemoglobin concentration algorithm). This probe scaling factor allows the hemoglobin concentration algorithm to be used with probe designs other than the 5 mm probe for which the algorithm is empirically created.

Claims

1. A method for measuring total concentration of a chromophore having at least two oxidation states in tissue, including:

   providing stored relationship data representative of lines or curves, the relationship data characterizing the relationship between second-derivative absorbance values at a first chromophore-absorbing wavelength and total concentration of the chromophore in a tissue at constant oxygenation;
   receiving a first second-derivative absorbance value from a tissue being analyzed at the first chromophore-absorbing wavelength;
   receiving oxygenation data from the tissue being analyzed representative of the value of the portion of the chromophore in the tissue being analyzed having an oxidation state, using conventional algorithms and a scaled second second-derivative absorbance value at a second wavelength; and
   generating data representative of the total concentration of the chromophore in the tissue being analyzed as a function of the line or curve of constant oxygenation of the chromophore associated with the received oxygenation data and the received first second-derivative absorbance value.

2. The method of claim 1, wherein the chromophore is hemoglobin, and wherein:

   providing the stored relationship data includes providing data representative of lines or curves of constant percent oxygenation of hemoglobin (%StO2);
   receiving oxygenation data includes receiving data representative of a percent oxygenation of hemoglobin (%StO2); and
   generating data representative of the total concentration of hemoglobin includes generating the data as a function of the line or curve of constant percent oxygenation of hemoglobin (%StO2) associated with the received data representing the percent oxygenation of hemoglobin (%StO2) and the received first second-derivative absorbance value.

3. The method of claim 1 or 2, further including the step of:

   determining validity of the oxygenation data as a function of the data representative of the total concentration of the chromophore.

4. The method of claim 3, further including the step of:

   providing a display indicating the validity of the oxygenation data.

5. The method of claim 2, wherein the first chromophore-absorbing wavelength is 760 nm.

6. The method of claim 2, wherein the data representative of the percent oxygenation of hemoglobin (%StO2) includes the second second-derivative absorbance value at a second chromophore-absorbing wavelength.

7. The method of claim 6, wherein the data representative of the percent oxygenation of hemoglobin (%St02) includes a ratio of the second second-derivative absorbance value over the first second-derivative absorbance value.

8. The method of claim 6 or 7, wherein the second chromophore-absorbing wavelength is 720 nm.

9. The method of claim 8, wherein the first and second second-derivative absorbance values are calculated from absorbance values measured at each of 680 nm, 720 nm, 760 nm and 800 nm.

10. The method of claim 2, and further including the step of:

determining validity of the percent oxygenation of hemoglobin (%StO2) as a function of the data representative of the total concentration of hemoglobin.

11. The method of claim 10, and further including the step of:

providing a display indicating the validity of the percent oxygenation of hemoglobin (%StO2).

12. The method of one of the claims 1 to 11, wherein the oxygenation data includes a ratio of the first second-derivative absorbance value and the second second-derivative absorbance value.

Patentansprüche

1. Verfahren zur Messung der Gesamtkonzentration eines Farbträgers, der mindestens zwei Oxidationszustände in Gewebe aufweist, umfassend:

das Bereitstellen von gespeicherten Verhältnisdaten, die Linien oder Kurven darstellen, wobei die Verhältnisdaten das Verhältnis zwischen zweiten Ableitungen von Absorptionswerten bei einer ersten farbträgerabsorbierenden Wellenlänge und der Gesamtkonzentration des Farbträgers in einem Gewebe bei gleich bleibender Sauerstoffanreicherung kennzeichnen;

das Erhalten einer ersten zweiten Ableitung eines Absorptionswerts von einem Gewebe, das bei der ersten farbträgerabsorbierenden Wellenlänge analysiert wird;

das Erhalten von Sauerstoffanreicherungs-Daten von dem analysierten Gewebe, die den Wert des Anteils des Farbträgers in dem analysierten Gewebe darstellen, der einen Oxidationszustand aufweist, unter Verwendung eines herkömmlichen Algorithmus' und einer maßstabgerechten zweiten zweiten Ableitung eines Absorptionswerts bei einer zweiten Wellenlänge; und

das Erzeugen von Daten, die die Gesamtkonzentration des Farbträgers in dem analysierten Gewebe als eine Funktion der Linie oder Kurve der gleich bleibenden Sauerstoffanreicherung des Farbträgers darstellen, die den erhaltenen Sauerstoffanreicherungs-Daten und der erhaltenen ersten zweiten Ableitung des Absorptionswerts zugehörig ist.

2. Verfahren nach Anspruch 1, wobei der Farbträger Hämoglobin ist, und wobei
das Bereitstellen der gespeicherten Verhältnisdaten das Bereitstellen von Daten umfasst, die Linien oder Kurven der gleich bleibenden prozentualen Sauerstoffanreicherung von Hämoglobin (% StO_2) darstellen;
das Erhalten von Sauerstoffanreicherungs-Daten das Erhalten von Daten umfasst, die eine prozentuale Sauerstoffanreicherung von Hämoglobin (% StO_2) darstellen; und
das Erzeugen von Daten, die die Gesamtkonzentration von Hämoglobin darstellen, das Erzeugen der Daten als eine Funktion der Linie oder Kurve der gleich bleibenden prozentualen Sauerstoffanreicherung von Hämoglobin (% StO_2) umfasst, die den erhaltenen Daten, die die prozentuale Sauerstoffanreicherung von Hämoglobin (% StO_2) darstellen, und der erhaltenen ersten zweiten Ableitung des Absorptionswerts zugehörig ist.

3. Verfahren nach Anspruch 1 oder 2, weiterhin umfassend den folgenden Schritt:

Bestimmen der Gültigkeit der Sauerstoffanreicherungs-Daten als Funktion der Daten, die die Gesamtkonzentration des Farbträgers darstellen.

4. Verfahren nach Anspruch 3, weiterhin umfassend den folgenden Schritt:

Bereitstellen einer Anzeige, die die Gültigkeit der Sauerstoffanreicherungs-Daten anzeigt.

5. Verfahren nach Anspruch 2, wobei die erste farbträgerabsorbierende Wellenlänge 760 nm beträgt.

6. Verfahren nach Anspruch 2, wobei die Daten, die die prozentuale Sauerstoffanreicherung von Hämoglobin (%

StO_2) darstellen, die zweite zweite Ableitung des Absorptionswerts bei einer zweiten farbträgerabsorbierenden Wellenlänge umfassen.

7. Verfahren nach Anspruch 6, wobei die Daten, die die prozentuale Sauerstoffanreicherung von Hämoglobin (% StO_2) darstellen, ein Verhältnis der zweiten zweiten Ableitung des Absorptionswerts zur ersten zweiten Ableitung des Absorptionswerts umfassen.

8. Verfahren nach Anspruch 6 oder 7, wobei die zweite farbträgerabsorbierende Wellenlänge 720 nm beträgt.

9. Verfahren nach Anspruch 8, wobei die erste und zweite zweite Ableitung des Absorptionswerts aus Absorptionswerten errechnet sind, die jeweils bei 680 nm, 720 nm, 760 nm und 800 nm gemessen sind.

10. Verfahren nach Anspruch 2, und weiterhin umfassend den folgenden Schritt:

Bestimmen der Gültigkeit der prozentualen Sauerstoffanreicherung von Hämoglobin (% StO_2) als eine Funktion der Daten, die die Gesamtkonzentration von Hämoglobin darstellen.

11. Verfahren nach Anspruch 10, und weiterhin umfassend den folgenden Schritt:

Bereitstellen einer Anzeige, die die Gültigkeit der prozentualen Sauerstoffanreicherung von Hämoglobin (% StO_2) anzeigt.

12. Verfahren nach einem der Ansprüche 1 bis 11, wobei die Sauerstoffanreicherungs-Daten ein Verhältnis der ersten zweiten Ableitung des Absorptionswerts und der zweiten zweiten Ableitung des Absorptionswerts umfassen.

Revendications

1. Procédé de mesure de la concentration totale de l'hémoglobine d'un chromophore ayant au moins deux états d'oxydation dans le tissu, comprenant les étapes consistant à :

fournir des données relationnelles mémorisées représentant des lignes ou des courbes, les données relationnelles caractérisant la relation entre des valeurs d'absorbance par double dérivation à une première longueur d'onde absorbant le chromophore et la concentration totale du chromophore dans un tissu à oxygénation constante ;
recevoir une première valeur d'absorbance par double dérivation d'un tissu analysé à la première longueur d'onde absorbant le chromophore ;
recevoir les données d'oxygénation du tissu analysé, représentatives de la valeur de la portion du chromophore dans le tissu analysé ayant un état d'oxydation, en utilisant des algorithmes classiques et une seconde valeur d'absorbance par double dérivation à l'échelle à une seconde longueur d'onde ; et
générer des données représentatives de la concentration totale du chromophore dans le tissu analysé, en fonction de la ligne ou courbe d'oxygénation constante du chromophore associé aux données d'oxygénation reçues et à la première valeur d'absorbance par double dérivation reçue.

2. Procédé selon la revendication 1, dans lequel le chromophore est de l'hémoglobine; et dans lequel :

fournir les données relationnelles mémorisées comprend la fourniture de données représentatives des lignes ou courbes de pourcentage constant d'oxygénation de l'hémoglobine (% St02) ;
recevoir les données d'oxygénation comprend la réception de données représentatives d'un pourcentage d'oxygénation de l'hémoglobine (% St02) ; et
générer des données représentatives de la concentration totale de l'hémoglobine comprend la création de données en fonction de la ligne ou courbe de pourcentage constant d'oxygénation de l'hémoglobine (% St02) associée aux données reçues représentant le pourcentage d'oxygénation de l'hémoglobine (% St02) et la première valeur d'absorbance par double dérivation reçue.

3. Procédé selon la revendication 1 ou 2, comprenant en outre l'étape consistant à :

déterminer la validité des données d'oxygénation en fonction des données représentatives de la concentration

totale du chromophore.

4. Procédé selon la revendication 3, comprenant en outre l'étape consistant à :

fournir un affichage indiquant la validité des données d'oxygénation.

5. Procédé selon la revendication 2, dans lequel la première longueur d'onde absorbant le chromophore est 760 nm.

6. Procédé selon la revendication 2, dans lequel les données représentant le pourcentage d'oxygénation de l'hémoglobine (% StO2) comprennent la seconde valeur d'absorbance par double dérivation à une seconde longueur d'onde absorbant le chromophore.

7. Procédé selon la revendication 6, dans lequel les données représentatives de l'hémoglobine (% St02) comprennent un ratio de la seconde valeur d'absorbance par double dérivation par rapport à la première valeur d'absorbance par double dérivation.

8. Procédé selon la revendication 6 ou 7, dans lequel la seconde longueur d'onde absorbant le chromophore est 720 nm.

9. Procédé selon la revendication 8, dans lequel la première et la seconde valeurs d'absorbance par double dérivation sont calculées à partir de valeurs d'absorbance mesurées à chacune des longueurs d'onde 680 nm, 720 nm, 760 nm et 800 nm.

10. Procédé selon la revendication 2, et comprenant en outre l'étape consistant à :

déterminer la validité du pourcentage d'oxygénation de l'hémoglobine (% St02) en fonction des données représentatives de la concentration totale de l'hémoglobine.

11. Procédé selon la revendication 10, et comprenant en outre l'étape consistant à :

fournir un affichage indiquant la validité du pourcentage d'oxygénation de l'hémoglobine (% St02).

12. Procédé selon l'une des revendications 1 à 11, dans lequel les données d'oxygénation comprennent un ratio de la première valeur d'absorbance par double dérivation et de la seconde valeur d'absorbance par double dérivation.

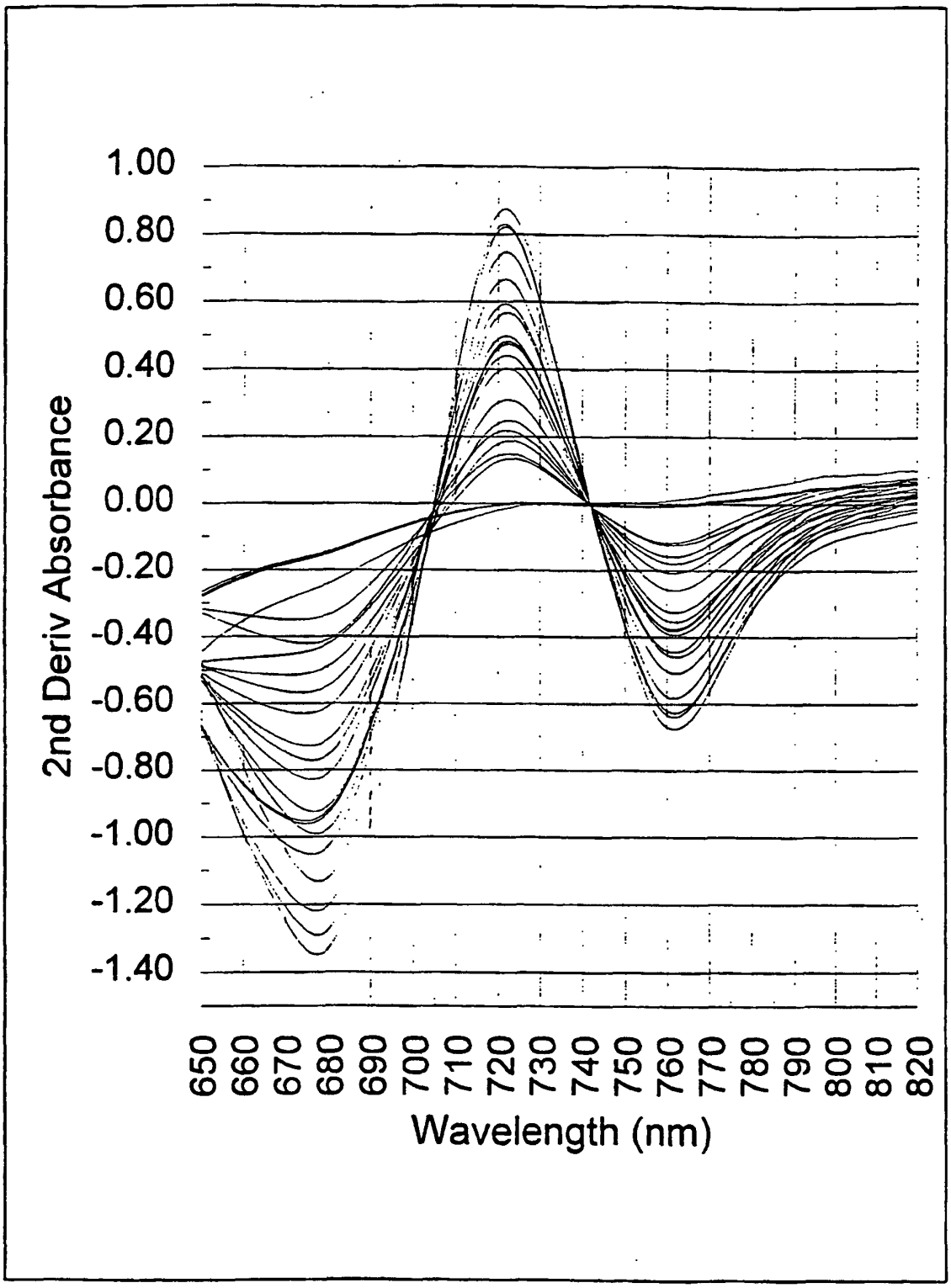
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
2nd Deriv Absorbance
650
660
670
680
690
700
710
720
730
740
750
760
770
780
790
800
810
820
Wavelength (nm)

Figure 1

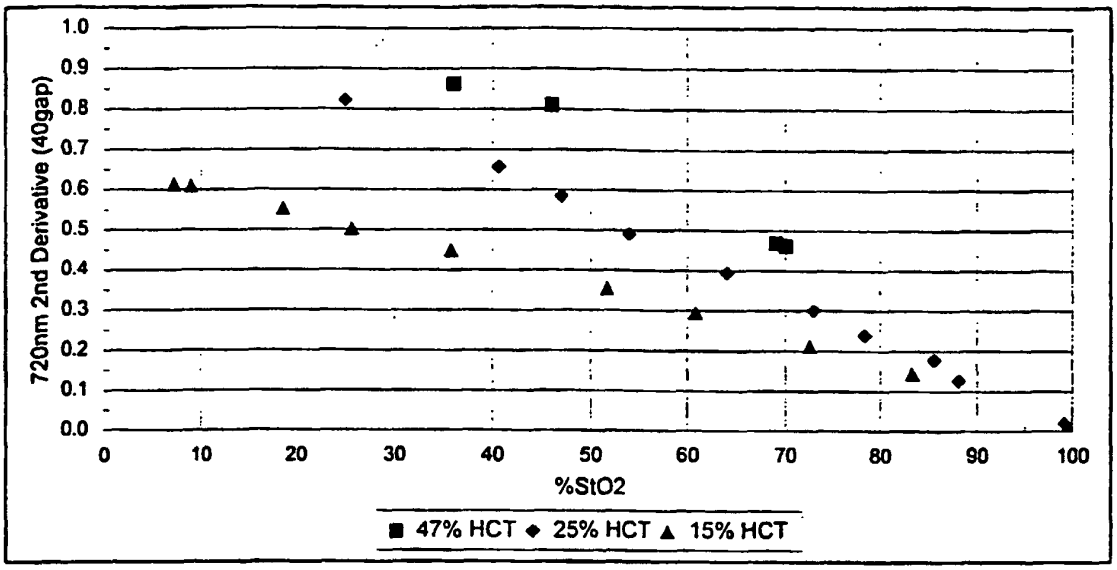

Figure 2

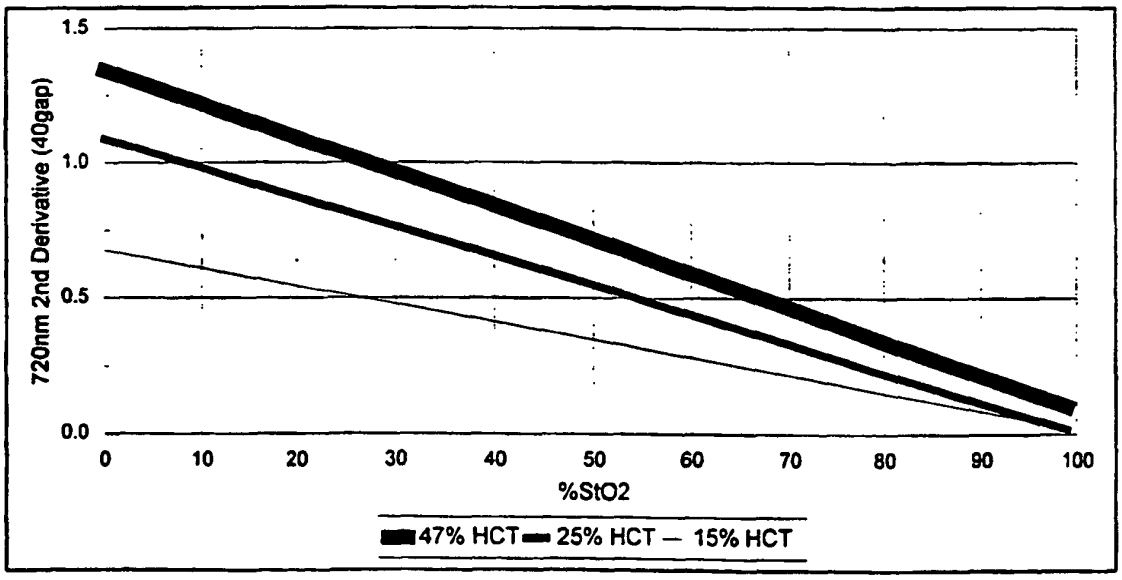

Figure 3

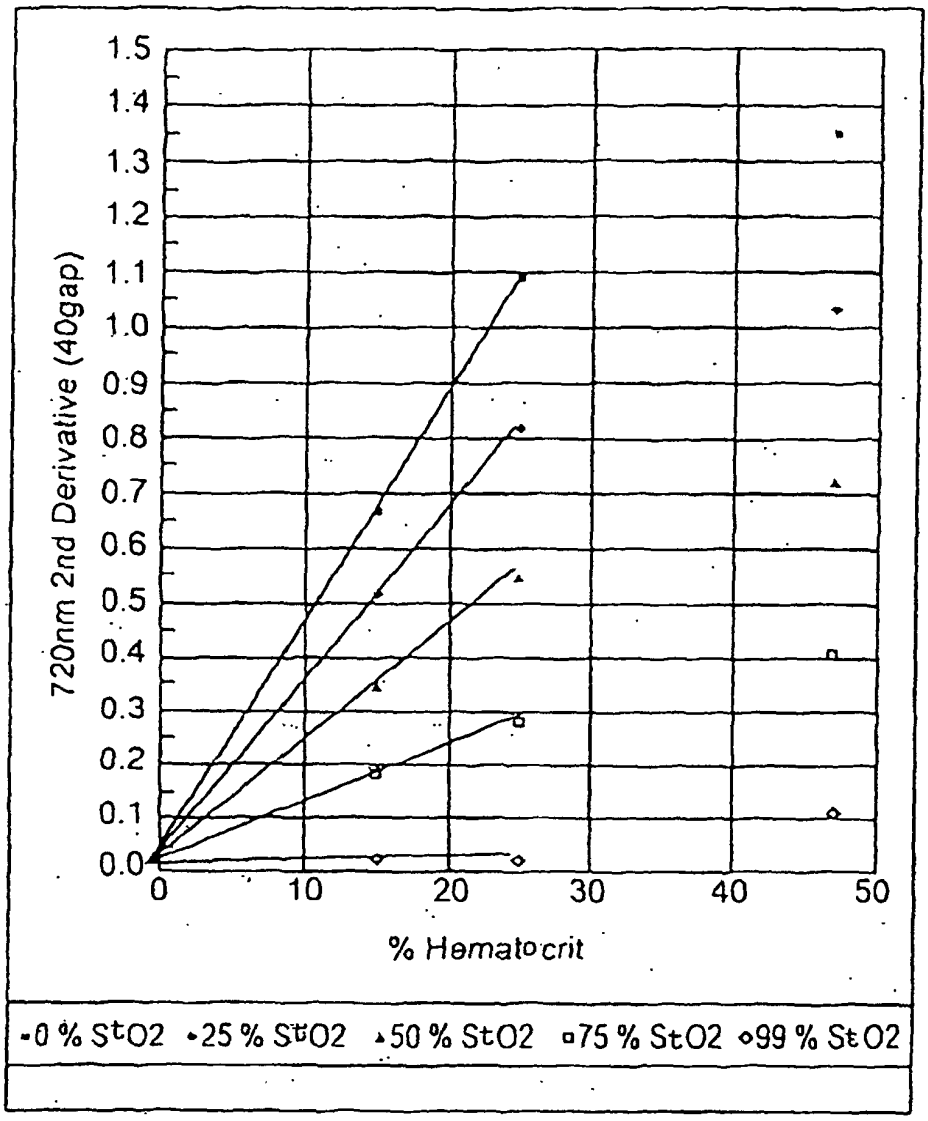
720nm 2nd Derivative (40gap)
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
% Hematocrit
0 % StO2
25 % StO2
50 % StO2
75 % StO2
99 % StO2

Fig. 4

%StO2	2nd680/2nd720	Hct Slope (Mso2)	%StO2	2nd680/2nd720	Hct Slope (Mso2)
0	-1.166	22.56	50	-1.670	44.28
1	-1.175	22.78	51	-1.684	45.15
2	-1.184	23.01	52	-1.699	46.06
3	-1.194	23.24	53	-1.713	47.00
4	-1.203	23.48	54	-1.727	47.98
5	-1.212	23.72	55	-1.741	49.00
6	-1.221	23.97	56	-1.755	50.07
7	-1.230	24.22	57	-1.770	51.19
8	-1.239	24.48	58	-1.784	52.35
9	-1.249	24.75	59	-1.798	53.57
10	-1.258	25.01	60	-1.812	54.85
11	-1.267	25.29	61	-1.826	56.19
12	-1.276	25.57	62	-1.841	57.60
13	-1.285	25.86	63	-1.855	59.08
14	-1.294	26.15	64	-1.869	60.64
15	-1.304	26.45	65	-1.883	62.28
16	-1.313	26.76	66	-1.897	64.02
17	-1.322	27.08	67	-1.921	65.85
18	-1.331	27.40	68	-1.932	67.80
19	-1.340	27.73	69	-1.954	69.86
20	-1.349	28.07	70	-1.990	72.05
21	-1.359	28.41	71	-2.050	74.38
22	-1.368	28.77	72	-2.080	76.87
23	-1.377	29.13	73	-2.120	79.54
24	-1.386	29.51	74	-2.150	82.39
25	-1.395	29.89	75	-2.190	85.46
26	-1.404	30.29	76	-2.230	88.76
27	-1.414	30.69	77	-2.270	92.33
28	-1.423	31.10	78	-2.310	96.20
29	-1.432	31.53	79	-2.350	100.42
30	-1.441	31.97	80	-2.400	105.01
31	-1.450	32.42	81	-2.450	110.05
32	-1.459	32.88	82	-2.500	115.60
33	-1.469	33.36	83	-2.550	121.75
34	-1.478	33.85	84	-2.600	128.58
35	-1.487	34.36	85	-2.660	136.24
36	-1.496	34.88	86	-2.730	144.86
37	-1.505	35.42	87	-2.800	154.66
38	-1.514	35.97	88	-2.880	165.90
39	-1.524	36.54	89	-2.960	178.91
40	-1.533	37.13	90	-3.050	194.16
41	-1.542	37.74	91	-3.150	212.28
42	-1.557	38.37	92	-3.270	234.19
43	-1.571	39.02	93	-3.400	261.23
44	-1.585	39.70	94	-3.580	295.49
45	-1.599	40.39	95	-3.750	340.40
46	-1.613	41.12	96	-4.040	402.03
47	-1.628	41.86	97	-4.500	492.44
48	-1.642	42.64	98	-5.510	639.77
49	-1.656	43.45	99	-9.650	931.66

Figure 5

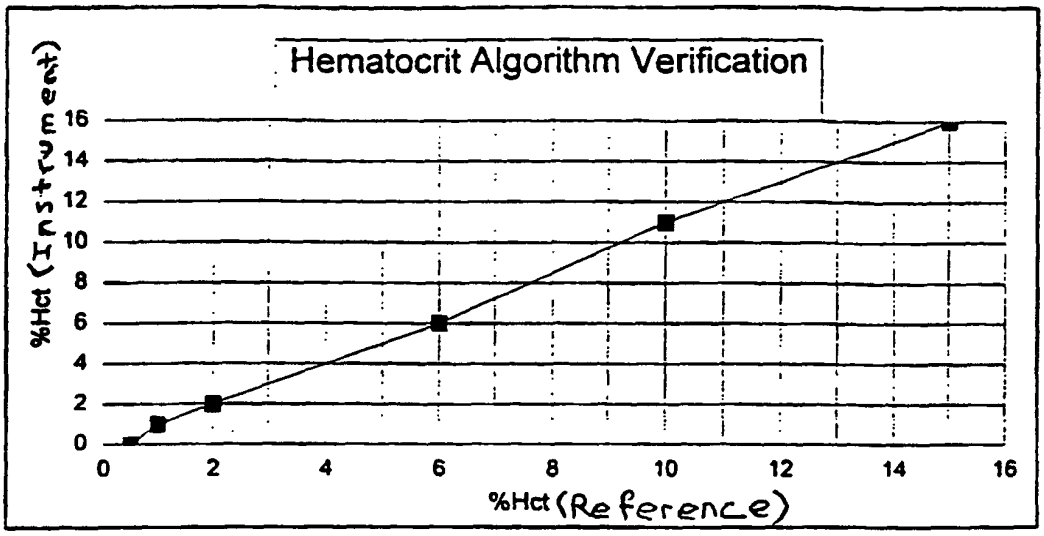

Figure 6

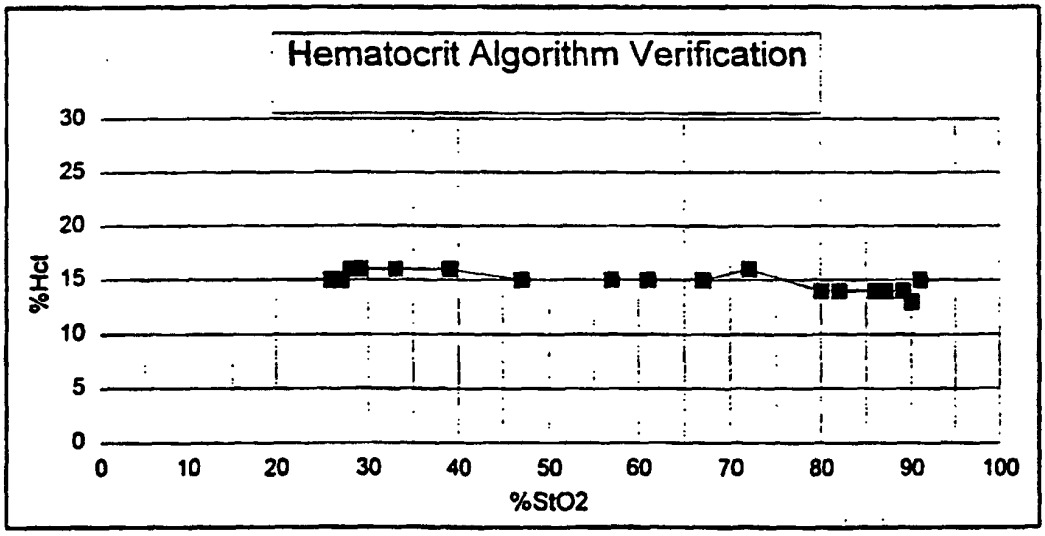

Figure 7

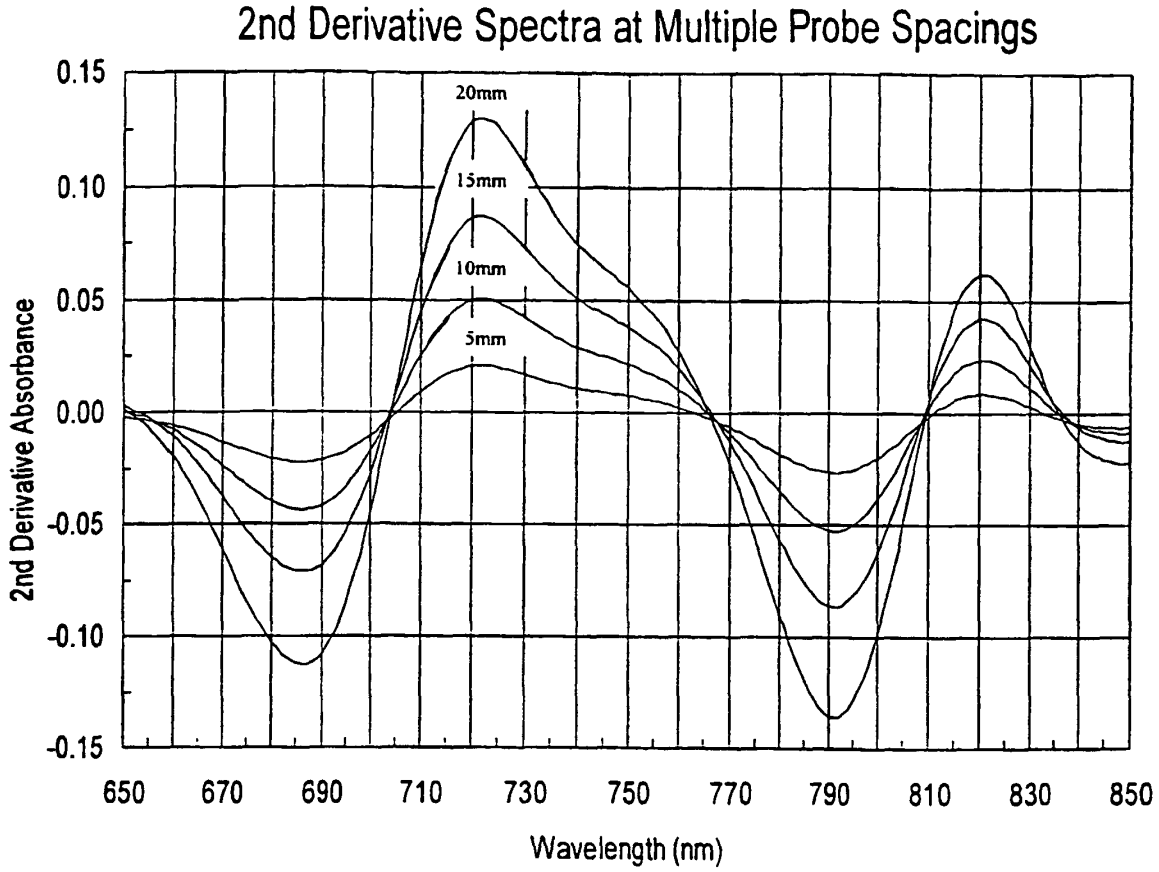
2nd Derivative Spectra at Multiple Probe Spacings
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
2nd Derivative Absorbance
20mm
15mm
10mm
5mm
650
670
690
710
730
750
770
790
810
830
850
Wavelength (nm)

Figure 8

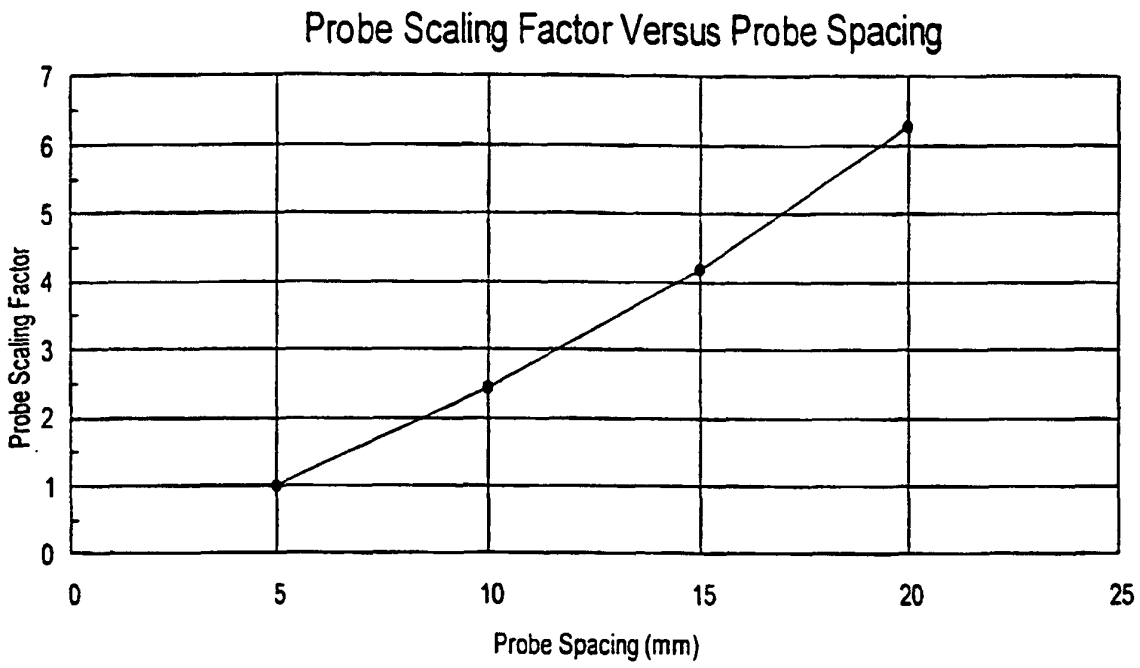
Probe Scaling Factor Versus Probe Spacing
Probe Scaling Factor
0
1
2
3
4
5
6
7
0
5
10
15
20
25
Probe Spacing (mm)

Figure 9

专利名称(译)	总血红蛋白浓度测量		
公开(公告)号	EP1196762B1	公开(公告)日	2005-11-23
申请号	EP2000942866	申请日	2000-06-16
[标]申请(专利权)人(译)	哈钦森技术股份有限公司		
申请(专利权)人(译)	HUTCHINSON TECHNOLOGY，INC.		
当前申请(专利权)人(译)	HUTCHINSON TECHNOLOGY，INC.		
[标]发明人	MYERS DEAN E		
发明人	MYERS, DEAN, E.		
IPC分类号	G01N33/483 A61B5/00 G01J3/433 G01N21/27 G01N21/35 G01N33/72		
CPC分类号	A61B5/7239 A61B5/1455 G01J3/433 G01N21/35 G01N21/3504		
优先权	60/139552 1999-06-16 US		
其他公开文献	EP1196762A1		
外部链接	Espacenet		

摘要(译)

一种操作分光光度计仪器的方法，该仪器用于测量组织中血红蛋白的氧合状态。该方法包括使用存储的血红蛋白浓度关系数据，该数据表征血红蛋白吸收波长的二阶导数吸光度值和组织中的血红蛋白浓度之间的关系，作为血红蛋白氧合状态的函数。接收表示正在分析的组织的二阶导数吸光度值的数据。组织的血红蛋白氧合状态被确定为二阶导数吸光度值的函数。然后根据血红蛋白浓度关系数据，二阶导数吸光度值和血红蛋白氧合状态确定组织中的血红蛋白浓度。血红蛋白氧合状态的准确度可以确定为血红蛋白浓度值的函数。