Fiber-based optic sensor for detecting human blood clot: present and future revival

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Abstract. Sustaining human’s life-frame away from being impeded by the clot - ghost term, we attempt to approach a mobile fiber-based optical sensor (f-s) for detecting blood clot in a blood vessel (intra-arteries/veins). Blood vessels are the part of the circulatory system that transport blood throughout the human body, thus their significance of being protected arise to the monograph focus. MRI (magnetic resonance imaging), X-rays and other medical instruments are diagnostic immobility techniques with a slacker interval. The corer causation of fiber-based optical sensor is to detect a clump of blood in the bloodstream by providing a prompt mobile diagnostic intervals preserving last-minutes breath of human’s life. The detector (f-s) has been etched by diluting sulphuric acid ~10% at certain zone to sensate its function. The in-vitro monograph peaks its maximal monitoring when the sensor is attached to Raman Spectroscopy (RS) setup. RS quantifies the relative intensities of fibrinogen bond, which is the first type of blood coagulation elements of blood plasma. Blood coagulation parameters are the major concern of the monograph investigation, such as total haemoglobin (tHb), clotting reaction time (t), clot progression time (t2), maximum clot amplitude (ma) and mean refractive index (r). A blood sample will be drawn from the patient and after centrifugation to separate blood plasma from its constituents, then an immediate sloshing of blood plasma in the (f-s) packet which has its plug-in to RS. Estimating the quantitative analysis of blood sample concentration, RS will determine the presence of coagulation in terms of intensity and medical procedures will dominate the treatment process. Thus, the suggestive monograph provides a definite instrument for investigating blood coagulation intra-arteries/veins promptly.

1. Introduction

Blood is the vital requirements of our body which supplies oxygen, nutrients, remove waste products and versatile positive functions. It includes plasma (the liquid portion), blood cells (which come in both red and white varieties), and cell fragments called platelets. Cells and platelets make up about 45% of human blood, while plasma makes out the other 55%. Blood plasma serves a variety of functions, from maintaining a satisfactory blood pressure and volume to supplying critical proteins from blood clotting and immunity. It also serves as the medium for exchange of vital minerals such as sodium and potassium and helps to maintain proper(acid-base) balance in the body, which is critical to cell function. Plasma is obtained by separating the liquid portion of blood from the cells. The combination between blood and clot has its quite specific scenario. One scenario, apparently, when the...
lining of a blood vessel is damaged, platelets are attracted to the wound site, where they form a sticky plug.

The platelets release signals, which not only attract other platelets and make them become form soluble protein present, a water fibrinogen cascade that ultimately converts signalling sticky, but also activate a signalling cascade that ultimately convert fibrinogen, a water-soluble protein present blood plasma, into fibrin (a non-water soluble protein). The fibrin forms threads that reinforce the platelet plug, making a clog that prevent further loss of blood [1,2]. According to biochemistry, the different molecules of the fibrinogen are connected by the peptide bombs and then fibrinogen clots come in into being [11]. The hazardous is the bloodstream clot which may have potentially significant consequences. Coagulopathy, a condition in which blood coagulation is impaired, can result from a variety of conditions including: obesity, pregnancy, immobility (including prolonged inactivity, long trips by plane or car), smoking, oral contraceptives, certain cancers, trauma, age (increased risk for people over age 60), a family history of blood clots, chronic inflammatory diseases, lack of physical activity, diabetes, high blood pressure and high cholesterol.

Intrinsically, optical fiber-based sensor (f-s) imprint its growing importance as an advance biomedical instrumentation to enable more efficient patient diagnosis, monitoring, and treatment. F-s is extremely immune to electromagnetic interference (EMI), chemically inert, nontoxic, and electromagnetic and radio frequency (RF) signals. Thus, it’s use will not cause interference with the conventional electronics found in medical theatres as well as during thermal ablative treatments involving RF or microwave radiation [3].

Biomedical (f-s) can be categorized into four main types: physical, imaging, chemical, and biological. Biological sensor is the major focus in the monograph whereas it tends to be more complex and rely on biologic recognition reactions—such as enzyme-substrate, antigen-antibody, or ligand-receptor which to identify and quantify specific biochemical molecules of interest [4,5]. As a rise of (f-s) dramatically in the biomedical domain, thus it becomes a giant option to detect blood clot (coagulation) precisely. The present invention relies on the finding that blood clot in a blood vessel generate a unit and specific spectrum detectable by Raman spectroscopy [6].

In particular, Raman spectroscopy in the near infrared (NIR) range measures vibrational transitions in molecules, so it can detect structural and clinical medical character of material in molecules in molecular level. In addition, its signal is more intense in high wave number region than in fingerprint region which consequently contribute to further improving the sensitivity to tissue pathological changes [7,8].

2. Experimental Setup and Data Processing

Fiber-based optical sensor applied for the monograph has been etched by diluting sulphuric acid (etching) ~ 10%. The packet for the blood collection demonstrates the sensing zone that had been etched by the etchant as in Figure 1.

Raman scattering happens wherein a laser photon of well-defined energy is scattered off a molecule, a small amount of energy is lost to a molecular vibration so the spectrum of the scattered light shows its sharp peak spectral features, characteristics for each molecule. In our monograph, we will obtain Raman spectrum of normal and suspected person’s blood plasma using FT (Fourier Transform) -Raman spectrometer with the exciting wavelength 1064nm.
Figure 1. Experimental setup

The major distinction of blood plasma is its relative intensities, especially in the wavenumbers of 800-950 cm\(^{-1}\) and 1530-1570 cm\(^{-1}\). The near-infrared (1064nm) excitation offers higher powered lasers to be used without photo degradation of the sample. Blood plasma is prepared by spinning a tube of fresh blood containing an anticoagulant in a centrifuge until the blood cells fall to the bottom of the tube. The blood plasma is then poured or drawn off [12]. Blood plasma has normal density of approximately 2-4 g/L. If the fibrinogen in the blood reaches a certain level (That is to say, if fibrinogen is more than 2-4 g/L), then the peptide bonds of fibrinogen would possibly change into some stable fibrinogen clots [13].

With this exertion, conformational and structural features of human blood will be studied by spectroscopic techniques with particular reference to relative intensities of fibrinogen peptide bond [9,10]. As well as featuring the monograph parameters such as total haemoglobin (tHb), clotting reaction time (t), clot progression time (t2), maximum clot amplitude (ma) and mean refractive index (r). Samples of whole blood will be drawn from different gender of average age about 50.0 ± 12.6.

3. Results

Figure 2 (a) shows the reference concentrations of fibrinogen, coagulation time, clot progressing time and time expected wavenumber for coagulation, (b) and (c) predict that the clotting might take place in Raman shift below 2500 cm\(^{-1}\) with the sharpest peak. Fiber-based optical sensor facilitates the sensation zone in the range less than the reference concentration through the predicted sharpest peaks.
Figure 2. (a) Raman shift below predict that the clotting might take place and (b) and (c) are the wavenumber for coagulation.

4. Conclusion
The method provides an opportunity to detect abnormal fibrinogen in terms of intensities. Hence it appears that the fiber-based optical sensor and Raman spectroscopic method will show a high potential for analysis of blood plasma in the whole blood. The drawback of those systems (F-s and Raman spectroscopy) is that although they may identify a vessel obstruction (e.g. blood clot), they are unable to localize the obstruction. As an expectation, F-s is a highly reproducible technique in the detection of clot signals in a complex biomedical matrix. The method and instrumentation demonstrated in the monograph are under great prediction and observation of present and future revival.

5. Ethical and Consideration
An official letter will be issued from University Technology Malaysia to demonstrate the blood drawing in clinics or hospitals wherein Raman spectroscopy is employed. Furthermore, revealing genetic information has important ethical implications for individuals as family members. The way
that a society governs the disclosure of such information and the extent to which its laws or other regulatory frameworks control what can be disclosed. For instance, we ought, ethically, to seek consent from people to use their genetic information in research because doing so respects their autonomy and freedom to choose.

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