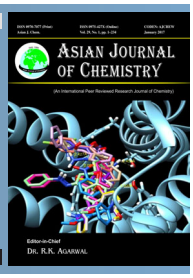
Asian Journal of Chemistry; Vol. 29, No. 4 (2017), 703-706

ASIAN JOURNAL OF CHEMISTRY

https://doi.org/10.14233/ajchem.2017.20399



MINI REVIEW

Infrared and Raman Spectroscopy in Diagnosis of Infectious Diseases

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Received: 8 November 2016; *Accepted*: 15 December 2016; *Published online*: 31 January 2017; AJC-18229

There are a few techniques which are widely utilized for identification of epidemiologic diseases, including ELISA, PCR, immune fluorescent test and Western blotting, which have been utilized for the diagnosis of epidemiologic diseases. However the reality of the situation is none of them is great regarding cost-viability, speed and precision. At this moment, the rate of flare-up of rising infections is expanding definitely and in this manner the improvement and foundation of explanatory techniques for such popular infections are turning out to be more essential. Near infrared spectroscopy is a quick, multivariate measure that empowers non-prominent, non-ruinous examination. As of late, the finding of viral diseases utilizing near infrared spectroscopy has been endeavoured.

Keywords: Infectious diseases, Infrared and Raman spectroscopy, Diagnosis.

INTRODUCTION

Infectious diseases are a leading cause of death worldwide. The essential driver of death from disease is sepsis. It happens when the body's reaction to a contamination harms its own tissues and organs [1]. Successful treatment of contamination depends on auspicious distinguishing proof of the concentration, the pathogen and its antibiotic resistance design to choose the fitting antibiotic treatment as right on time as could be allowed. Solid strategies accelerating the present set up deve-lopment based microbiological examination and techniques to stratify the patients are of most extreme intrigue. Raman spectroscopy as a mark free and non-damaging procedure holds a high potential for the spectroscopic characterization of disease. Development of free Raman-based recognizable proof techniques require capturing of the microscopic organisms in the laser center. This can be accomplished utilizing dielectro-phoresis or outward powers on a lab-on-circle microfluidic stages [2-4]. With both methodologies pathogens can be recognized specifically from body liquids inside a couple of minutes including test readiness as exhibited for pee tests from patients experiencing urinary tract diseases. In times of rising antibiotic resistances, additionally the antibiotic susceptibility of the pathogen must be resolved. Exemplarily, the spectro-scopic examination of the medication target cooperations of vancomycin, a glycopeptide antibiotic, with enterococci is introduced [5]. Changes in the bacterial Raman spectra because of antibiotic treatment can be recognized effectively following 30 min of treatment. Not generally microbes are dwelling in body liquids, but rather they can cover up inside cells and make troublesome treat intra-cell contaminations. A progressed Raman-based approach is displayed to restrict and portray intracellular *Staphylococcus aureus* in three measurements without the need of any outer name. An aberrant strategy to analyze contaminations, includes evaluation of the host reaction upon pathogen invasion by recording a hemogram [6-9].

The idea of utilizing vibrational spectroscopic strategy as adjunct medicinal symptomatic devices goes back over a large portion of a century to a period when infrared spectroscopy was itself in its early stages; yet and after it's all said and done, forward-looking spectroscopists thought about the likelihood of utilizing the biochemical data realistic by spectroscopic strategies, as opposed to the morphological data ordinarily utilized as a part of established cytopathology and histopatho-logy, for therapeutic findings. Notwithstanding, it truly took until the main decade of the 21st century that the guarantee for otherworldly cytopathology (SCP, spectral diagnosis of cells) and phantom histopathology (SHP, spectral diagnosis of tissue) got to be functional [10-13]. Propels in the spectroscopic endeavours were colossally supported by associative change in estimation innovation in the mid-2000s and a hazardous development of computational power accessible to spectro-scopists. Strikingly, according to the creators, the expanded

computational power, alongside the advancement of some fundamental theoretical underpinnings, was the most essential improvement to propel SCP and SHP toward the business domain [4,14,15].

FTIR spectroscopy: The interferometric principle of Fourier transform infrared (FTIR) spectrometers include the multiplex, the throughput and the wavenumber accuracy advantage named after Felgett, Jacquinot and Connes, respectively. The fundamental approach in implementing an interferometer to obtain two-dimensional, laterally resolved IR spectra requires the detected radiation to define a specific region of a sample. This lateral localization is expert in two optical configurations [16,17]. Mapping techniques restrict radiation at the sample plane by an aperture. Imaging techniques segment radiation at the detection plane by IR-sensitive multi-channel detectors, termed focal plane array (FPA) detectors. A methodological extension includes three-dimensional FTIR imaging which analyzes multiple tissue sections by FTIR imaging and reconstruct them by image processing techniques.

The majority of the research conducted in previous three decades on NIR spectroscopy in the medicinal domain depended on oxygenated or deoxygenated hemoglobin. This work has been generally utilized for analysis of diseases as well as useful examinations of mind and muscle. This is on the ground that near infrared radiation is generally communicable in the NIR region. The qualities of near infrared radiation empower non-risky and non-prominent investigation *in vivo*. However, paying little respect to being a fitting system for the finding of viral infection, NIR spectroscopy has barely been utilized as a part of the field of virology. The estimation of near infrared spectroscopy as an examination instrument is just start to figure out. The future ought to see extending usage of near infrared spectroscopy in the field of virology for assurance, tedious investigation, research tests to distinguish viral contamination, examination of the pathological infection related to disease, estimation of infection load, *etc*. Moreover, as NIR spectroscopy is reasonable *in vivo* examination, NIR spectroscopy might be material for autopsy tests for prion diseases, for example, bovine spongiform encephalopathy (BSE) [2,18-22]. Multivariate investigations, for example, incomplete partial least-squares regression analysis (PLS), principal component regression analysis (PCRA), principal component analyses (PCA) and soft independent modelling of class analogy (SIMCA) are the most valuable techniques for breaking down near infrared spectra. One essential outcome of the advancement of near infrared spectroscopy has been the acknowledgement of the significance of exact band assignment. One usually utilized band task technique is substitution of isotope. However, this strategy can't be connected for most bioprecursors, for example, proteins, lipids and sugars, in light of the fact that the band task of such biomolecules is troublesome because of the complexities of these hydrogen-bearing particles [23,24]. Few reviews endeavoured to utilize NIR spectroscopy to foresee the centralization of recombinant proteins, yet there have been couple of such attempts. This is on ground that the absorption of minor constituents, for example, recombinant proteins might be effectively overpowered by more exceptional groups from other part, like solvents. In the event that band task utilizing fractionated biomolecules were conceivable, utilizations of near infrared spectroscopy will be incredibly extended. The Crucial issue is the retention of biomolecules in the near infrared district is short. To conquer these issues of NIR spectroscopy, the utilization of near infrared fluorescent colour named tests or solvents may build specificity and offer ascent to a straight relationship between biomolecule focused. Besides, an exceptionally delicate location strategy for NIR spectroscopy has been produced. This technique in view of retention delicate surface plasmon reverberation accomplished 100 times improvement of absorbance [16,25-29].

Raman spectroscopy: For a long time, tissue fluorescence and the absence of appropriate, sensitive instrumentation were essential impediments in the biomedical use of Raman spectroscopy. At the point when organic utilizations of Raman spectroscopy began around over 30 years prior, it took numerous hours to record spectra of exceptionally purged and focused arrangements of biomolecules. The issue of fluorescence, which overcomes the Raman signal of most regular natural specimens (counting natural tissues) upon excitation in the visible region, has been to a great extent overcome by the accessibility of instruments working in the NIR area of the range. Fluorescence in Raman spectra from biomolecules can be maintained a strategic distance from by laser excitation in the profound UV in light of the fact that a without fluorescence window exists with excitation below 270 nm [30-33]. In any case, deep UV excitation additionally harbors the risk of prompting photo degradation harm. The most ordinarily utilized Raman imaging instrument comprises of a NIR strong state laser, a magnifying lens with a mechanized specimen arrange, a Notch channel for Rayleigh diffusing scattering, a dispersive spectrometer and a charge coupled device (CCD) camera which is streamlined for the NIR area [34-37]. Flag accumulation times could be decreased to the point where just seconds are required to get Raman spectra of cells and tissues. The time takes to gather a Raman signal is obviously urgent in Raman imaging applications as the spectra are typically gathered consecutively in the mapping mode and the aggregate securing time is the result of information focuses increased when per range/point. Time is additionally an imperative issue *in vivo* applications in view of tissue development brought about by respiratory and vascular pulsations [38,39].

Detection and identification of clinical relevant pathogens under defined laboratory conditions: A fast, reliable and identification of the pathogen bringing about an irresistible disease is critical for the right determination and fitting treatment. Built up systems in the clinical microbiology include tedious development ventures to recognize phenotypic properties in the development or biochemical attributes of the isolated pathogen. Elective systems that officially discovered their way into the centers are PCR-based strategies that recognize microorganisms from their DNA or lattice helped laser desorption ionization time-of-flight investigations speaking to various protein designs. Raman spectroscopic systems hold a high potential to bring extra advantage for a quick and exact analysis [37,40-42].

Current updates and complications in the detection of epidemic infections: Initial and complex identification of

epidemiologic contamination is fundamental for the circulation of smooth blood supply, management of epidemiologic diseases and counteractive action of transmission. The danger of transfusion-related communication of infections, for example, human immunodeficiency infection (HIV) [43], hepatitis B infection (HBV) [44], hepatitis C infection (HCV) and human T-cell lymphotropic infection (HTLV) has been diminished by the advent of advanced sensitive serological tests [45]. In any case, the possibility of epidemiologic infections, for example, epidemiologic infection that is still in the pre-seroconversion window period, contamination with immunovariant infections and disease comprising of immunosilent carriage still demolishes. A few strategies, for example, ELISA and PCR have been used for the identification of infections from persons among the pre-seroconversion window period. ELISA is economically accessible, dependable and particular. ELISA covers just a slender scope of infection antigens and is tedious and costly. PCR is grouping particular [46,47]. The affectability of PCR is a few requests of greatness than those of regular serological tests. However, PCR might be not appropriate for large scale tedious screening. To diminish the budget of PCR, pooled plasma has been consumed to observe substantial quantities of tests, however the pooling technique decreases the affectability to an indistinguishable point from that of ELISA. To think infected elements, ultracentrifugation has utilized, however ultracentrifugation leads to maximum incorrect results [48]. Moreover, a high rate of false-positive and false-negative results because of bungle ground works for subtypes of infections has likewise been accounted for the PCR technique. Besides, specific precautionary measures are required to maintain a strategic distance from cross-sullying in PCR investigations. As of late, multiplex PCR measures for infections have been created. That technique is marginally enhanced as far as cost-adequacy and time, yet does not address alternate restrictions of PCR [49,50]. In this manner, the advancement of a precise, quick and minimal effort strategy for the determination of infections in view of novel ideas are required.

REFERENCES

1. J.C. de Jong, E.C. Claas, A.D. Osterhaus, R.G. Webster and W.L. Lim, *Nature*, **389**, 554 (1997); https://doi.org/10.1038/39218.
2. G.L. Campbell, A.A. Marfin, R.S. Lanciotti and D.J. Gubler, *Lancet Infect. Dis.*, **2**, 519 (2002); https://doi.org/10.1016/S1473-3099(02)00368-7.
3. D.A. Heaps and P.R. Griffiths, *Vib. Spectrosc.*, **41**, 221 (2006); https://doi.org/10.1016/j.vibspec.2006.03.005.
4. L. Mertz, *Infrared Phys.*, **7**, 17 (1967); https://doi.org/10.1016/0020-0891(67)90026-7.
5. P.T.T. Wong, R.K. Wong, T.A. Caputo, T.A. Godwin and B. Rigas, *Proc. Natl. Acad. Sci. USA*, **88**, 10988 (1991).
6. K.V. Ramana, M.A. Kareem, C. Sarada, S. Sebastian, R. Lebaka, M.S. Ratnamani and R. Rao, *Indian J. Pathol. Microbiol.*, **53**, 574 (2010); https://doi.org/10.4103/0377-4929.68280.
7. Y.-T. Liu, *Infect. Disord. Drug Targets*, **8**, 183 (2008); https://doi.org/10.2174/1871526510808030183.
8. R. Sindhuphak, S. Issaravanich, V. Udomprasertgul, P. Srisookho, S. Warakamin, S. Sindhuphak, R. Boonbundarlchai and N. Dusitsin, *Gynecol. Oncol.*, **90**, 10 (2003); https://doi.org/10.1016/S0090-8258(03)00196-3.
9. B.R. Wood, L. Chiriboga, H. Yee, M.A. Quinn, D. Mcnaughton and M. Diem, *Gynecol. Oncol.*, **93**, 59 (2004); https://doi.org/10.1016/j.ygyno.2003.12.028.
10. S. Mordechai, R.K. Sahu, Z. Hammody, S. Mark, K. Kantarovich, H. Guterman, A. Podshyvalov, J. Goldstein and S. Argov, *J. Microsc.*, **215**, 86 (2004); https://doi.org/10.1111/j.0022-2720.2004.01356.x.
11. M. Khanmohammadi and A.B. Garmarudi, *Trends Analyt. Chem.*, **30**, 864 (2011); https://doi.org/10.1016/j.trac.2011.02.009.
12. K.M. Ostrowska, A. Garcia, A.D. Meade, A. Malkin, I. Okewumi, J.J. O'Leary, C. Martin, H.J. Byrne and F.M. Lyng, *Analyst*, **136**, 1365 (2011); https://doi.org/10.1039/c0an00910e.
13. K.V. Ramana and K.S. Reddy, *Br. J. Med. Med. Res.*, **3**, 1929 (2013); https://doi.org/10.9734/BJMMR/2013/3759.
14. K.V. Ramana, *Ann. Trop. Med. Public Health*, **5**, 279 (2012); https://doi.org/10.4103/1755-6783.101988.
15. K.V. Ramana and P.G. Kranti, *Ann. Med. Health Sci. Res.*, **2**, 211 (2012); https://doi.org/10.4103/2141-9248.105679.
16. A. van Belkum, M. Welker, M. Erhard and S. Chatellier, *J. Clin. Microbiol.*, **50**, 1513 (2012); https://doi.org/10.1128/JCM.00420-12.
17. K.V. Ramana, S. Kandi, V. Bharatkumar, C.H.V. Sharada, R. Rao, R. Mani and S.D. Rao, *Am. J. Inf. Dis. Microbiol.*, **1**, 64 (2013); https://doi.org/10.12691/ajidm-1-4-2.
18. J.S. Peiris, S.T. Lai, L.L. Poon, Y. Guan, L.Y. Yam, W. Lim, J. Nicholls, W.K. Yee, W.W. Yan, M.T. Cheung, V.C. Cheng, K.H. Chan, D.N. Tsang, R.W. Yung, T.K. Ng and K.Y. Yuen, *Lancet*, **361**, 1319 (2003); https://doi.org/10.1016/S0140-6736(03)13077-2.
19. C. Schmaljohn and B. Hjelle, *Emerg. Infect. Dis.*, **3**, 95 (1997); https://doi.org/10.3201/eid0302.970202.
20. C. Featherstone, *Lancet*, **349**, 930 (1997); https://doi.org/10.1016/S0140-6736(05)62711-0.
21. M.P. Barrett, *Lancet*, **353**, 1113 (1999); https://doi.org/10.1016/S0140-6736(98)00416-4.
22. L.H. Taylor, S.M. Latham and M.E.J. woolhouse, *R. Soc. Lond. Biol.*, **356**, 983 (2001); https://doi.org/10.1098/rstb.2001.0888.
23. E.W. Ciurczak and J.K. Drennen, Practical Spectroscopy Series: Pharmaceutical d Medical Applications of Near-Infrared Spectroscopy, Marcel Dekker Inc, New York (2002).
24. H.W. Siesler, Y. Ozaki, S. Kawata and H.M. Heise, Near-Infrared Spectroscopy: Principles, Instruments, Applications, Wiley-VCH., Weinheim (2002).
25. M. Germain, S. Ge'linas and G. Delage, *Can. Med. Assoc. J.*, **170**, 1077 (2004); https://doi.org/10.1503/cmaj.1031936.
26. I. Loussert-Ajaka, F. Brun-Vézinet, F. Simon, T.D. Ly, M.L. Chaix, S. Saragosti, A.M. Couroucé and D. Ingrand, *Lancet*, **343**, 1393 (1994); https://doi.org/10.1016/S0140-6736(94)92524-0.
27. W. Kaye, *Spectrochim. Acta*, **6**, 257 (1954); https://doi.org/10.1016/0371-1951(54)80011-7.
28. K.H. Norris, *J. Near Infrared Spectrosc.*, **4**, 31 (1996); https://doi.org/10.1255/jnirs.941.
29. R.A. Shaw, S. Kotowich, H.H. Mantsch and M. Leroux, *Clin. Biochem.*, **29**, 11 (1996); https://doi.org/10.1016/0009-9120(95)02011-X.
30. D.E. Honigs, J.M. Freelin, G.M. Hieftje and T.B. Hirschfeld, *Appl. Spectrosc.*, **37**, 491 (1983); https://doi.org/10.1366/0003702834634631.
31. A.E. Nikulin, B. Dolenko, T. Bezabeh and R.L. Somorjai, *NMR Biomed.*, **11**, 209 (1998); https://doi.org/10.1002/(SICI)1099-1492(199806/08)11:4/5<209::AID-NBM510>3.0.CO;2-5.
32. P.M. Fredericks, J.B. Lee, P.R. Osborn and D.A.J. Swinkels, *Appl. Spectrosc.*, **39**, 303 (1985); https://doi.org/10.1366/0003702854248999.
33. S.A. Klein, S. Karsten, B. Rüster, C. Klebba, M. Pape, O.G. Ottmann, D. Hoelzer and W.K. Roth, *J. Virol. Methods*, **107**, 169 (2003); https://doi.org/10.1016/S0166-0934(02)00230-6.
34. J. Saldanha, N. Lelie, A. Heath, WHO Collaborative Study Group, *Vox Sang.*, **76**, 149 (1999); https://doi.org/10.1046/j.1423-0410.1999.7630149.x.
35. K.Z. Liu, A. Man, R.A. Shaw, B. Liang, Z. Xu and Y. Gong, *Biochim. Biophys. Acta*, **1758**, 960 (2006); https://doi.org/10.1016/j.bbamem.2006.05.006.

36. M. Diem, L. Chiriboga and H. Yee, *Biopolymers*, **57**, 282 (2000); https://doi.org/10.1002/1097-0282(2000)57:5<282::AID-BIP50>3.0.CO;2-R.
37. M. Jackson, B. Ramjiawan, M. Hewko and H.H. Mantsch, *Cell. Mol. Biol.*, **44**, 89 (1998).
38. K.M. Gough, D. Zelinski, R. Wiens, M. Rak and I.M. Dixon, *Anal. Biochem.*, **316**, 232 (2003); https://doi.org/10.1016/S0003-2697(03)00039-3.
39. K.Z. Liu, I.M. Dixon and H.H. Mantsch, *Cardiovasc. Pathol.*, **8**, 41 (1999); https://doi.org/10.1016/S1054-8807(98)00024-6.
40. C. Krafft, R. Salzer, G. Soff and M. Meyer-Hermann, *Cytometry A*, **64A**, 53 (2005); https://doi.org/10.1002/cyto.a.20117.
41. E. Gazi, J. Dwyer, N. Lockyer, P. Gardner, J.C. Vickerman, J. Miyan, C.A. Hart, M. Brown, J.H. Shanks and N. Clarke, *Faraday Discuss.*, **126**, 41 (2004); https://doi.org/10.1039/b304883g.
42. B.W. de Jong, C.A. de Gouveia Brazao, H. Stoop, K.P. Wolffenbuttel, J.W. Oosterhuis, G.J. Puppels, R.F. Weber, L.H. Looijenga and D.J. Kok, *J. Urol.*, **171**, 92 (2004); https://doi.org/10.1097/01.ju.0000101948.98175.94.
43. M.C. Prieto, P. Matousek, M. Towrie, A.W. Parker, M. Wright, A.W. Ritchie and N. Stone, *J. Biomed. Opt.*, **10**, 44006 (2005); https://doi.org/10.1117/1.1991848.
44. K. Potter, L.H. Kidder, I.W. Levin, E.N. Lewis and R.G.S. Spencer, *Arthritis Rheum.*, **44**, 846 (2001); https://doi.org/10.1002/1529-0131(200104)44:4<846::AID-ANR141>3.0.CO;2-E.
45. N.P. Camacho, P. West, P.A. Torzilli and R. Mendelsohn, *Biopolymers*, **62**, 1 (2001); https://doi.org/10.1002/1097-0282(2001)62:1<1::AID-BIP10>3.0.CO;2-O.
46. N.P. Camacho, P. West, M.H. Griffith, R.F. Warren and C. Hidaka, *Mater. Sci. Eng. C*, **17**, 3 (2001); https://doi.org/10.1016/S0928-4931(01)00326-5.
47. C.P. Schultz, M.K. Ahmed, C. Dawes and H.H. Mantsch, *Anal. Biochem.*, **240**, 7 (1996); https://doi.org/10.1006/abio.1996.0323.
48. R.A. Shaw, S. Kotowich, H.H. Eysel, M. Jackson, G.T.D. Thomson and H.H. Mantsch, *Rheumatol. Int.*, **15**, 159 (1995); https://doi.org/10.1007/BF00301774.
49. B.L. Horecker, *J. Biol. Chem.*, **148**, 173 (1973).
50. N. Stone, C. Kendall, N. Shepherd, P. Crow and H. Barr, *J. Raman Spectrosc.*, **33**, 564 (2002); https://doi.org/10.1002/jrs.882.