**Lesson Plan: Lecture 20**

**Green Analytical Chemistry**

**Description**

In this class students will learn about Green Analytical Chemistry. The lecture includes information about analytical method assessment, including tools and techniques for assessing the greenness of methods. The lecture addresses sample preparation, analytical techniques and methods including chromatography and spectroscopy, and Process Analytical Technology (PAT).

**Prior to Lecture**

Optional/ Supplemental Readings:

Green Analytical Chemistry articles:

* Vanhoenacker, G., Sandra, P., David, F., Sandra, K., Pereira, A., 2010, Green chromatography (Part 1): Introduction and liquid chromatography, LC-GC Europe, 23, 242-259
* “Green Analytical Chemistry” by Paul Ferguson and Douglas Raynie, in Green Techniques for Organic Synthesis and Medicinal Chemistry, 2nd Edition, Zhang, W. and Cue, B. W., Eds., Wiley, 2018, pp. 43-66
* M. Koel, M. Kaljurand, *Crit. Rev. Anal. Chem.*, **42**, 192-195 (2012).
* Galuszka, A., Migaszewski, Z., Namiesnik, J., 2013, The 12 principles of green analytical chemistry and the SIGNIFICANCE mnemonic of green analytical practices, Trends Anal. Chem., 50, 78-84
* Galuszka, A., Konieczka, P., Migaszewski, Z. Namiesnik, J., 2012, Analytical eco-scale for assessing the greenness of analytical procedures, Trends Anal. Chem., 37, 61-72
* Tobiszewski, M., Namiesnik, J., 2015, Scoring of solvents used in analytical laboratories by their toxicological and exposure hazards, Ecotox. Environ. Safety, 120, 169-173
* Tobiszewski, M., Marc, M., Galuszka, A., Namiesnik, Molecules, 2015, 20, 10928-10946, doi:10.3390/molecules200610928 (Open-Access article) (File name: Green Chemistry Metrics with Special Reference to Green Analytical Chemistry.pdf)
* Keith, L. K., Gron, L. U., Young, J. L., Chem. Rev., 2007, 106, 6, 2695-2708
* National Environmental Methods Index (NEMI): <https://www.nemi.gov/about/> (searchable database for analytical methods, includes a greenness metric)
* R. Helmy, R. Hartman, C. J. Welch, and M. Al-Sayah, *Green Chem.,* 2011, **13**, (934-939)

Solvent Selection articles:

* Dunn and Perry, et. al., Green Chem., 2008, 10, 31-36
* Henderson, R.K., et. al., Green Chem., 2011, 13, 854
* American Chemical Society’s Green Chemistry Institute Pharmaceutical Roundtable, <http://www.acs.org/content/acs/en/greenchemistry/industry-business/pharmaceutical.html>
* Solvent replacements for chromatography: Taygerly, J.P., Peterson, E.A., *et. al*., Green Chemistry, 2012, 14, 3020-3025

Additional background information:

* For more information on X-ray fluorescence: ThermoFisher, <https://www.thermofisher.com/us/en/home/industrial/spectroscopy-elemental-isotope-analysis/spectroscopy-elemental-isotope-analysis-learning-center/elemental-analysis-information/xrf-technology.html>
* For more information on IR spectroscopy: Compound Interest, <https://www.compoundchem.com/2015/02/05/irspectroscopy/>
* For more information on Raman Spectroscopy: NanoPhoton, <https://www.nanophoton.net/raman/raman-spectroscopy.html>

Videos/Web materials

* Green Analytical Chemistry webinar by Dr. Douglas Raynie, South Dakota State University, February 3, 2016: <https://www.beyondbenign.org/webinar/implementing-green-chemistry-introductory-analytical-course/>

**Topics to Cover in Lecture**

* What is Green Analytical Chemistry?
* Analytical Method Assessment
  + Tools and Techniques for Assessing Greenness of Analytical Methods
* Sample Preparation
* Analytical Techniques and Methods
  + Chromatography
  + Spectroscopy
  + Mass spectrometry
* Process Analytical Technology (PAT)