

1) PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title: The synthesis and characterization of a novel material for green analytical methods

1.1. Project goals

- Synthesis and development of novel stationary phases for chromatographic techniques that allow performing chromatographic separation using pure water as a mobile phase
- Synthesis and development of novel stationary phases for chromatographic techniques that allow performing chromatographic separation using ethanol-water mixture (green solvents)
- Synthesis and development of novel stationary phases with versatile properties that may be operated in RP LC, HILIC, and in purely water mobile phase, including anion- and cation-exchange properties.
- Synthesis and development of novel stationary phase for solid phase extraction.
- Development of green analytical methods, including sample preparation (solid phase extraction) and chromatographic separation.

1.2. Outline

Conventional chromatographic analyses performed in reversed-phase liquid chromatography (RP LC), normal phase (NP LC), or in hydrophilic interactions liquid chromatography (HILIC), generate a significant amount of toxic waste. On the other hand, modern analytical chemistry cannot exist without chromatography and solid phase extraction. Developments in the pharmaceutical industry show a need for new chromatographic materials that offer the selectivity to separate a variety of increasingly new chemical compounds. There is a lack of such materials that can be used environmentally friendly.

Therefore, new solutions are being sought to reduce or completely eliminate organic solvents or change them to "green" solvents, such as ethanol. One of them is using pure water as the only component of the mobile phase. Another one is to change parameters of analysis such as temperature, which will allow performing separation faster and with reduced use of organic modifiers. Thus, the main objective of this project is to synthesize new materials that offer various chromatographic selectivity, selective sorption properties, and may be operated in pure water during liquid chromatography analyses.

1.3. Work plan

- Synthesis of novel stationary phases for solid phase extraction and for liquid chromatography (enhanced with computer modeling using SCIGRESS software)
- Physico-chemical characterization of obtained materials
- Chromatographic characterization of materials (sorption properties, adsorption

mechanism, possibility of application in reversed-phase, hydrophilic interaction liquid chromatography, ion-exchange chromatography, etc.)

- Application of obtained sorbents in extraction methods (development of green extraction methods)
- Application of stationary phases in liquid chromatography (development of green chromatographic methods)

1.4. Literature (max. 10 listed, as a suggestion for a PhD candidate)

- 1) Bocian, S., Krzemińska, K., The separations using pure water as a mobile phase in liquid chromatography using polar-embedded stationary phases. *Green Chem. Lett. Rev.* 2019, 12, 69–78.
- 2) Welch, C. J., Wu, N., Biba, M., Hartman, R., Brkovic, T., Gong, X., Helmy, R., Schafer, W., Cuff, J., Pirzada, Z., Zhou, L., Greening analytical chromatography. *TrAC - Trends Anal. Chem.* 2010, 29, 667–680.
- 3) Płotka, J., Tobiszewski, M., Sulej, A. M., Kupska, M., Górecki, T., Namieśnik, J., Green chromatography. *J. Chromatogr. A* 2013, 1307, 1–20.
- 4) Bocian, S., Nowaczyk, A., Buszewski, B., New alkyl-phosphate bonded stationary phases for liquid chromatographic separation of biologically active compounds. *Anal. Bioanal. Chem.* 2012, 404, 731–740.
- 5) S. Armenta, S. Garrigues, F. A. Esteve-Turrillas, M. de la Guardia, *Green extraction techniques in green analytical chemistry*, TrAC Trends in Anal. Chem., 2019, 116, 248-253
- 6) M. Tobiszewski, A. Mechlińska and J. Namieśnik, *Green analytical chemistry—theory and practice*, Chem. Soc. Rev., 2010, 39, 2869-2878
- 7) F. Chemat, M. Abert-Vian, A. Sylvie Fabiano-Tixier, J. Strube, L. Uhlenbrock, V. Gunjevic, G. Cravotto, *Green extraction of natural products. Origins, current status, and future challenges*, TrAC Trends in Anal. Chem., 2019, 118, 248-263

7.1. Required initial knowledge and skills of the PhD candidate

knowledge of Polish and English, analytical thinking, eagerness to learn, knowledge of analytical chemistry, knowledge about advanced instrumental techniques, knowledge in the field of liquid chromatography

7.2. Expected development of the PhD candidate's knowledge and skills

Acquisition of the ability to synthesize and characterize chemically bound stationary phases for liquid chromatography and extraction techniques, the ability to develop, optimize and validate analytical methods, and acquisition of the ability to write scientific papers.