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| **Title and Code** of the subject:**Hyphenated analytical methods MTMEL7015A** | **ECTS Credit Points: 3** |
| **Type** of the subject: compulsory |
| **Ratio of theory and practice: 50/50 %**  |
| **Type and number of classes per semester**: 14 hours lecture and 14 hours practice per **semester** Number of teaching hours / week: 1+1 (lecture and practice) |
| **Type of exam**: exam mark |
| **Subject in the curriculum:** semester 3 |
| Preliminary requirements:- |

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| **Summary of content - theory**:  |
| Course objectives:The students get acquainted with the grouping and applicability of the most important attached analytical systems. The students will get a detailed educational material (theoretical and practical knowledge) for the most important attached analytical systems (HPLC–UV/VIS and HPLC–DAD, HPLC–ICP-MS, LC-MS, GC-MS). It will detail the importance and process of the speciation analytics, moreover, it will give specific examples for application of an attached analytical system.***The topics of the lectures:*****1. week:** grouping of the attached techniques.**2-3. weeks:** application possibilities of HPLC–UV/VIS and HPLC–DAD systems**4-5. weeks:** separation and detection possibilities of elemental speciation analytical methods (HPLC–ICP-OES, HPLC–ICP-MS, moreover non-chromatographic analytical methods)**6. week:** advantages and disadvantages of different elemental speciation analytical methods**7-8. weeks:** sampling and sample preparation methods for elemental speciation analytical methods**9. week:** application possibilities of a liquid chromatograph mass spectrometer (LC-MS)**10. week:** application possibilities of gas chromatograph mass spectrometer (GC-MS)**11. week:** introduction and possibilities of analytical techniques of arsenic species**12. week:** introduction and possibilities of analytical techniques of selenium species**13. week:** introduction and possibilities of analytical techniques of mercury species**14. week:** introduction and possibilities of analytical techniques for species of other elements |
| **Summary of content - practice**: |
| ***The topics of laboratory exercises:*****1. week:** education of prevention of accidents, introduction of laboratory order and each laboratory exercises**2-3. weeks:** sampling and sample preparation methods of food raw materials and food productions for elemental speciation analyses**4-5. weeks:** sampling and sample preparation methods of food raw materials and food productions for determination of organic compounds**6-8. weeks:** analysis of chromium(III) and chromium(VI) species contents in the previously prepared samples of food raw material and food production using aluminium-oxide micro column and inductively coupled plasma optical emission spectrometer (MC–ICP-OES).**9-11. weeks:** analysis of selenium(IV) and selenium(VI) species contents in the previously prepared samples of food raw material and food production using ion chromatograph and inductively coupled plasma mass spectrometer (IC–ICP-MS).**12-14. weeks:** identification and analysis of contents of various organic compounds in the previously prepared samples of food raw material and food production using gas chromatograph–mass spectrometer |
| **Literature, handbooks in English**  |
| 1. Cornelis, R., Crews, H., Caruso, J., Heumann, K. 2003. Handbook of Elemental Speciation: Techniques and Methodology John Wiley & Sons, Ltd. ISBN: 0-471-49214-0
2. Cornelis, R., Crews, H., Caruso, J., Heumann, K (editor) 2005. Handbook of Elemental Speciation II: Species in the Environment, Food, Medicine & Occupational Health. John Wiley & Sons, Ltd. ISBN: 0-470-85598-3 (HB)
3. Ure, A.M., Davidson, C.M. 2002. Chemical Speciation in the Environment, Blackwell Science Ltd. ISBN 0-632-05848-X
4. Joanna Szpunar, J., Lobinski, R. (Editors) 2003. Hyphenated Techniques in Speciation Analysis. The Royal Society of Chemistry. Cambridge, UK. 252 p. ISBN: 978-0-85404-545-7

Ruth Waddell, Cris Lewis, Wei Hang, Chris Hassell and Vahid Majidi: (2005) Inductively Coupled Plasma Mass Spectrometry for Elemental Speciation: Applications in the New Millennium. Applied Spectroscopy Reviews, 40:33–69. |
| **Competencies gained** *(acc. to the Regulation on training and outcome requirements)* |
| **Knowledge:*** The students have to know the basic principles of laboratory examination for food technology and food safety analysis.

**Skills:*** The students have to have the ability to learn laboratory techniques, taking into account the environmental and health protection standards, and applying new methods in the whole area of food production.

**Attitude:*** They have to be receptive to learn the needed theory, in order to understand, how the equipments and tools, used in food industry, functions.

**Autonomy and responsibility:*** They have to be receptive to learn the needed theory, in order to understand how the equipments and tools, used in food industry, function.
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| **Responsible lecturer: Prof. Dr. Béla Kovács, professor, PhD** |
| **Other lecturer(s): Dr. Áron Béni**  |

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| **Terms of course completion:** |
| Completing assignments / exercisesSubmitting essayGiving presentation |
| **Form of examination:** |
| Oral or written exam |
| **Requirement(s) to get signature:** |
| Participate in the practices and successful practice tests |

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| **Exam questions:** |
| 1. What is the main purpose of using hyphenated systems?
2. What is orthogonal system means? Please write down some examples.
3. Present a typical hyphenated system. Write down some examples to “hyphenation” and

“multiple hyphenation” systems.1. What does „decomposition” mean? Explain it with at least two examples.
2. What are the differences between „decompostion” and „physical loss”?
3. What kinds of interface can you list? Explain it with examples.
4. How can UV/VIS be incorporated in a hyphenated system in terms of physical

(order) arrangement?1. What kinds of limitation might the HPLC show up in terms of connectivity to UV/VIS

detection?1. What kinds of compounds can be analysed with HPLC-UV/VIS?
2. What kinds of eluents are usually used for HPLC-UV/VIS?
3. List the advantages and disadvantages of HPLC-UV/VIS systems.
4. How to improve the selectivity of HPLC-UV/VIS systems?
5. What are the basic features of derivatization in the case of HPLC-UV/VIS applications?
6. What are the most important advantages of derivatization in the case of

HPLC-UV/VIS applications?1. Why is peak purity test required? How it is done?
2. What is speciation?
3. Why is chemical speciation important? Please give min. 2 examples!
4. Which kind of compounds can be measured by HPLC-ICP-MS system?
5. What kind of eluent can we use in HPLC-ICP-MS hyphenated system?
6. What is the typical flow rate, pH range and purity of the eluent in HPLC-ICP-MS hyphenated system?
7. List the advantages and disadvantages of HPLC-ICP-MS systems.
8. What kinds of analytes can be / cannot be analysed with HPLC-ESI-MS?
9. How does the ESI ion source work?
10. Present the ESI-MS compatible HPLC parameters (flow rate, pH, eluents).
11. Compare “soft” and “hard” ionisation.
12. What kinds of things influence the ion intensity of analytes in ESI ion sources?
13. Present the general application areas of the two main branches of ESI-MS instrumentations.
14. How can the identity of a given analyte be proven in HPLC-ESI-Q(Q)Q-MS?
15. What does a monoisotopic mass mean?
16. What does an isotopologue mean?
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