



NANOWORLD COMES TO SECONDARY SCHOOLS IN THE CZECH REPUBLIC

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CONTENT

- What is the nanoworld?
- Should we teach about the nanoworld at secondary schools?
- Educational materials concerning the nanoworld
- Demonstrations concerning the nanoworld
- Czech database of “nanodemonstrations“
- Summary



WHAT IS THE NANOWORLD?



<http://kotanec.wsn.cz/image/340/5284>

- “nanos” – Greek word for dwarf
- prefix **nano-** = 10^{-9}

- **nanoworld** encompasses particles and structures with size range from 1 nm to 100 nm
- different or enhanced physical, chemical and biological properties of **nanoparticles and nanostructures**
- interdisciplinary fields – **nanotechnology and nanoscience**



SHOULD WE TEACH ABOUT THE NANOWORLD AT SECONDARY SCHOOLS?

- nanoworld – interesting field, well known from media
- popular and promising area of research
- a lot of useful applications

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Čeští vědci objevili, jak vyrábět nanovlákná

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Liberecké univerzitě se podařilo vytvořit technologii pro průmyslovou výrobu nanovláknenných materiálů. Používají se například při léčení popálenin nebo v chirurgii. Škola bude při výrobě přístrojů spolupracovat se soukromou společností.



<http://www.bobwards.com/prodimages/29808-DEFAULT-l.jpg>



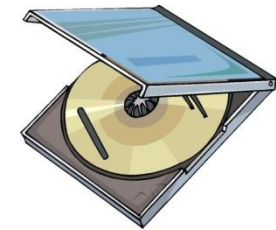
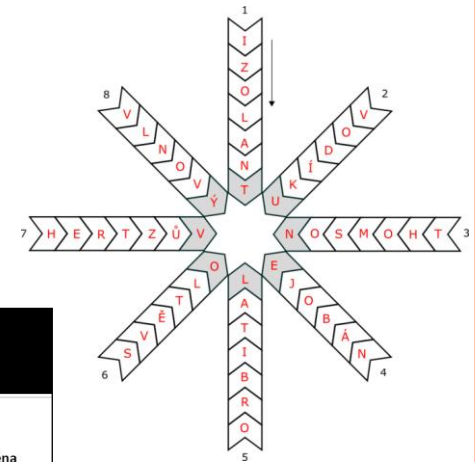
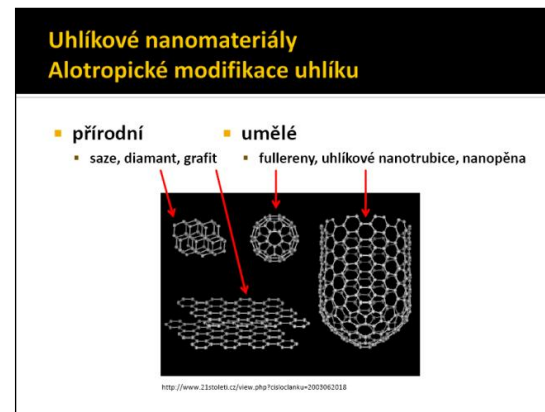
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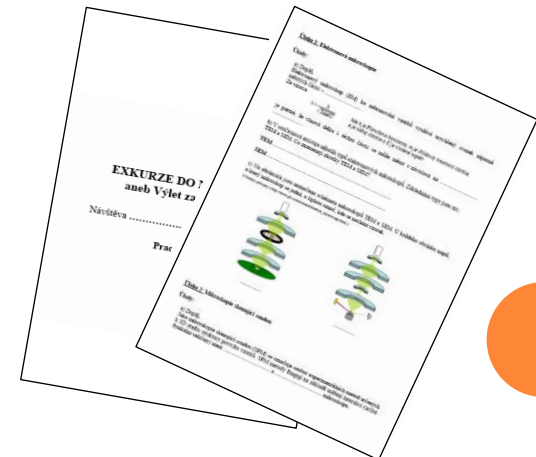
EDUCATIONAL MATERIALS CONCERNING THE NANOWORLD

○ prepared materials (Hájková, 2009):

- educational text
- multimedia presentation
- excursion concept
- concept of a project
- worksheets with tasks
- tests



○ additional educational materials and methodical concepts are needed

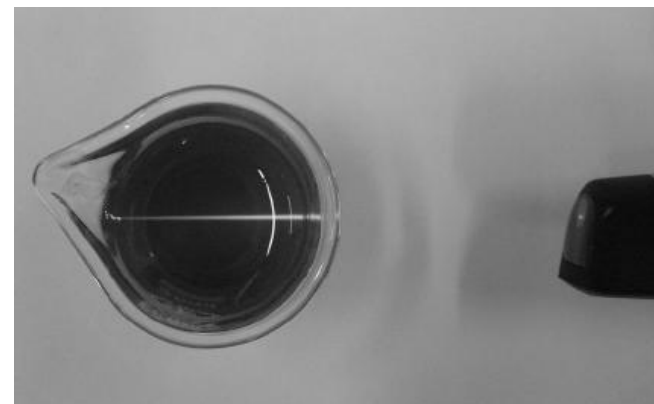


DEMONSTRATIONS CONCERNING THE NANOWORLD

- nanoworld is really small and rather abstract

- **experiments**

- **fullerenes**
(e.g., Kolář *et al.*, 2003)
- **silver nanoparticles**
(e.g., Soukupová *et al.*, 2010; Vaníčková *et al.*, 2010)
- **colloids**
(e.g., Panáček *et al.*, 2004; Panáček a Kvítek, 2005)
- BUT some phenomena from the nanoworld cannot be presented using real experiments



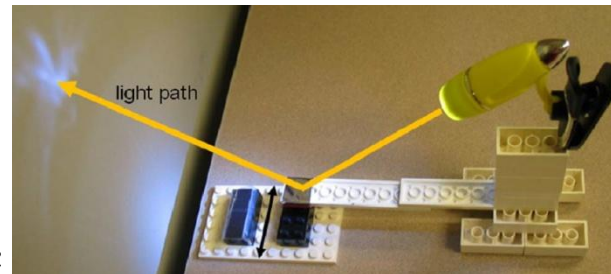
Vaníčková *et al.*, 2010



DEMONSTRATIONS CONCERNING THE NANOWORLD

○ “non-experimental“ demonstrations

- models, 3D analogies etc.
- **paper models of fullerenes**
(e.g., Beaton, 1992 and 1995; Boo, 1992; Kolář *et al.*, 1999; Hájková, 2011)
- **models of scanning probe microscope (SPM – STM, AFM)**
(e.g., Ashkenaz *et al.*, 2010; Bonson *et al.*, 2011; Campbell *et al.*, 1999; Lorenz *et al.*, 1997; Planinsic *et al.*, 2009; Hájková *et al.*, 2012)
- **booklet for modelling the materials and tools that work in the nanoworld with LEGO bricks** (Campbell *et al.*, 2012)
- **methodical manual with simple demonstrations and games concerning the “nanothemes”** (Tkáčová, 2011)



Campbell *et al.*, 2012



CZECH DATABASE OF “NANODEMONSTRATIONS”

○ containing 14 interdisciplinary “nanodemonstrations”

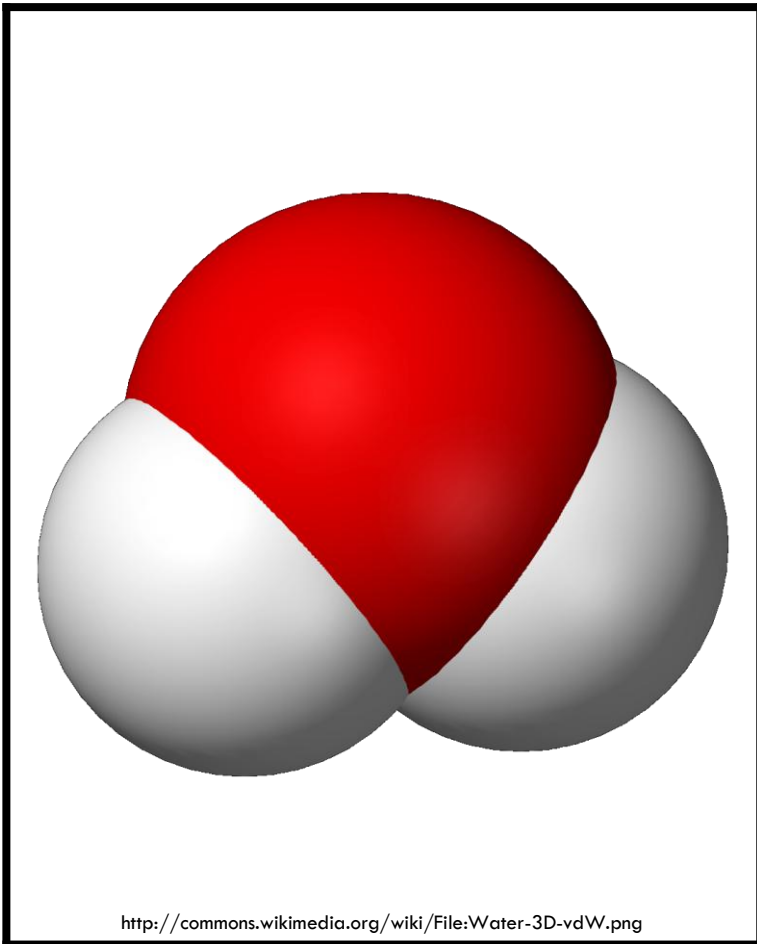
- simple
- cheap
- rather timesaving
- only household items required
- modified (and verified) demos as well as new demos
- chemistry, physics, science seminar etc.
- some “nanodemos” have already been tested
- in future: research aimed at the comparison of the effectiveness in using “nanodemonstrations” instead of interdisciplinary “nanotasks”



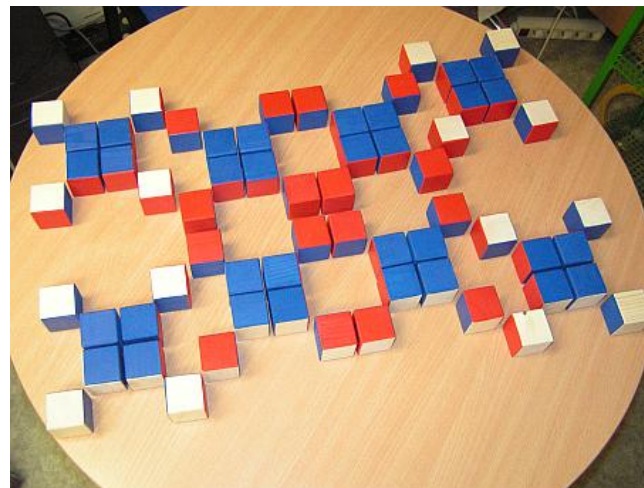
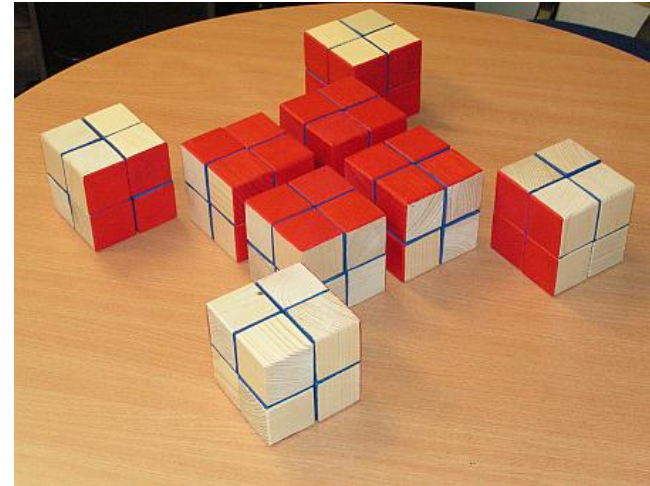
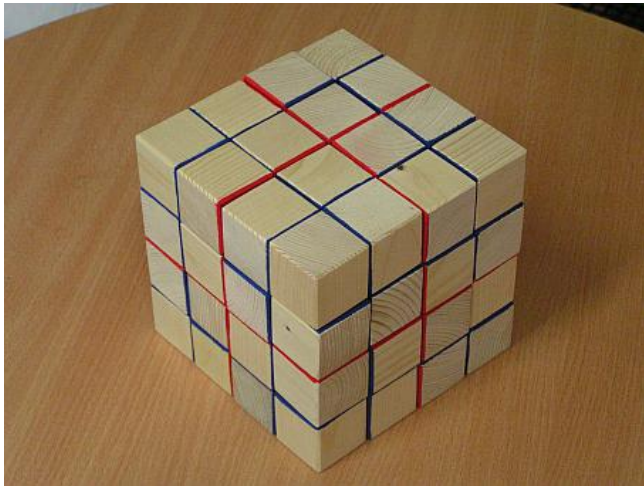
○ 5 chapters



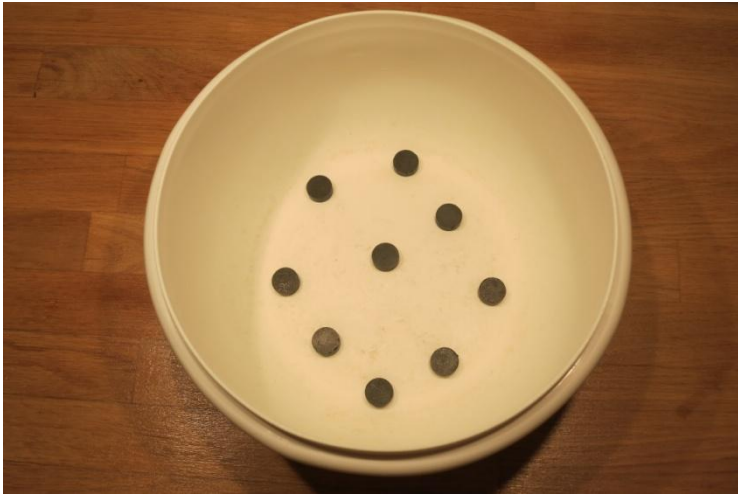
CHAPTER 1: WELCOME TO THE NANOWORLD: HOW BIG IS A “NANO”?



CHAPTER 2: UNUSUAL PROPERTIES OF NANOPARTICLES, NANOSTRUCTURES AND NANOMATERIALS



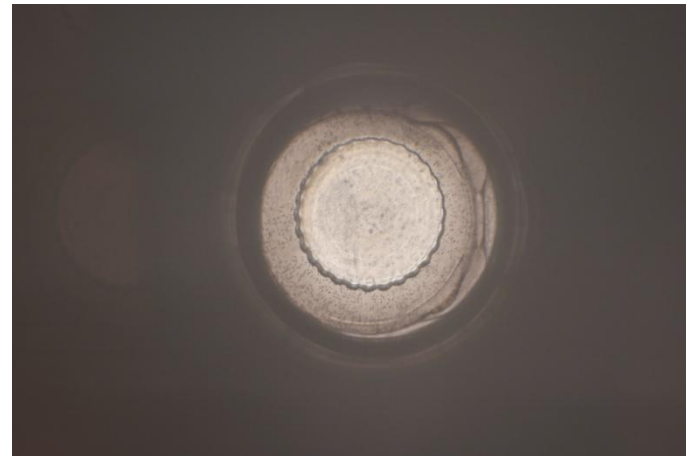
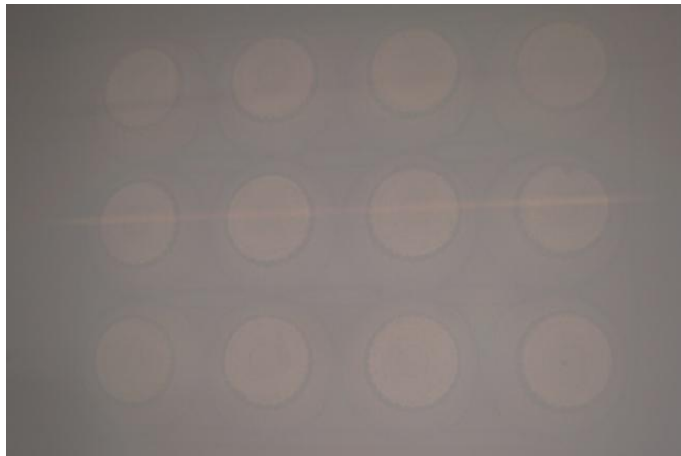
CHAPTER 3: APPROACHES TO “NANOMANUFACTURING”



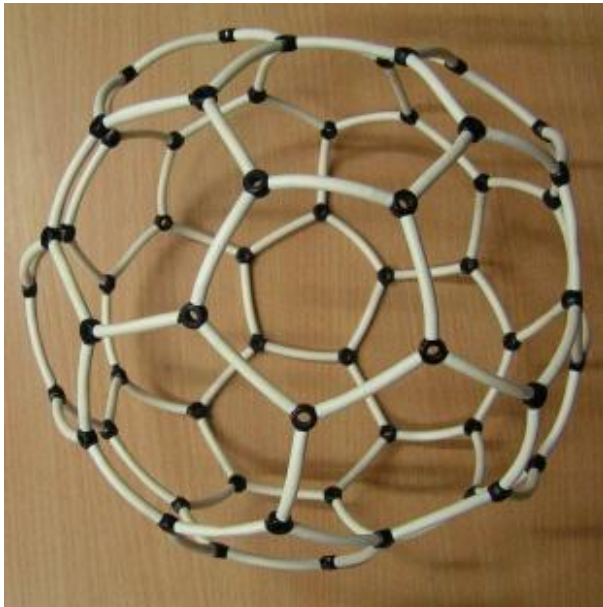
CHAPTER 4: SEEING AT THE NANOSCALE — ELECTRON MICROSCOPY



CHAPTER 4: SEEING AT THE NANOSCALE – SPM



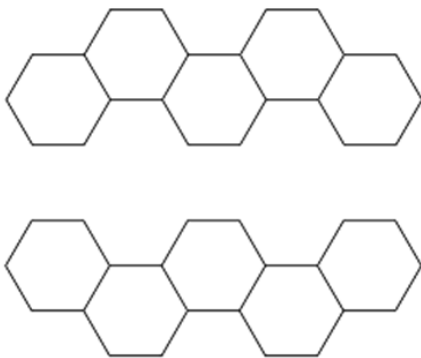
CHAPTER 5: CARBON “NANOALLOTROPES”



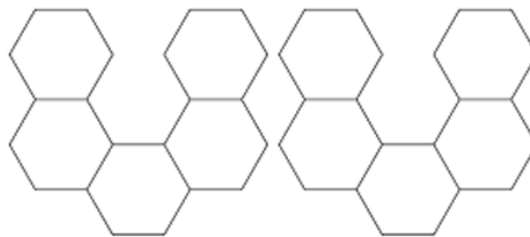
CZECH DATABASE OF “NANODEMONSTRATIONS”

○ scheme of demonstrations:

- each demo: theoretical introduction, materials, time for preparation and realization and in detail procedure of demonstration
- some demos: tips and tricks, additional tasks, materials for printing like templates, worksheets etc.



Template I



Template II



SUMMARY

- basics from the nanoworld should appear in the curriculum of science subjects at secondary schools
- Czech educational materials concerning the nanoworld were presented
 - database with 14 interdisciplinary “nanodemonstrations”
- “nanodemos“ can serve as useful visual aids
- additional materials are welcome to successfully implement the findings from the nanoworld to the science subjects at secondary schools in the Czech Republic



REFERENCES

- The Royal Society and the Royal Academy of Engineering. *Nanoscience and Nanotechnologies: Opportunities and Uncertainties*, 2004. Nanotechnology and Nanoscience. <http://www.nanotec.org.uk/finalReport.htm> (accessed September 27, 2012).
- Causes of color. *What causes the colors of metals like gold?* <http://www.webexhibits.org/causesofcolor/9.html> (accessed November 1, 2012).
- HÁJKOVÁ, Z. and ŠMEJKAL, P. Introducing „Nano“ in Chemistry Education at High Schools in the Czech Republic. In *Current Trends in Chemical Curricula*. Prague: Charles University in Prague, Faculty of Science, 2008, s. 14-18. ISBN 978-80-86561-60-8.
- HÁJKOVÁ, Z. *Návrh implementace nových poznatků z interdisciplinárního oboru „nanotechnologie“ do výuky přírodovědných předmětů na SŠ*. Praha: Univerzita Karlova, Přírodovědecká fakulta, Katedra učitelství a didaktiky chemie, 2009. Vedoucí diplomové práce RNDr. Petr Šmejkal, Ph.D. Materials are accessible at: <http://web.natur.cuni.cz/studiumchemie/materialy.php?obor=E&typ=>
- KOLÁŘ, K.; KMEŤOVÁ, J.; MYŠKA, K.; TOMEČEK, O. Experimenty s fullereny. *Biologie, chemie, zeměpis*, 2003, roč. 12, s. 85 – 88. ISSN 1210-3349.
- SOUKUPOVÁ, J.; KVÍTEK, L.; KRATOCHVÍLOVÁ, M.; PANÁČEK, A.; PRUCEK, R.; ZBOŘIL, R. Silver Voyage from Macro- to Nanoworld. *J. Chem. Educ.*, 2010, vol. 87, pp. 1094 – 1097. ISSN 0021-9584.
- VANÍČKOVÁ, M.; SOUKUPOVÁ, J.; KVÍTEK, L. Nanotechnologie ve výuce přírodních věd. *Chemické listy*, 2010, roč. 104, s. 945 – 949. ISSN 0009-2770.
- ASHKENAZ, D. E. *et al.* Coffee Cup Atomic Force Microscopy. *J. Chem. Educ.*, 2010, vol. 87, pp. 306–307.
- BEATON, J.M. A Paper-Pattern System for the Construction of Fullerene Molecular Models. *J. Chem. Educ.*, 1992, vol. 69, pp. 610 – 612.
- BEATON, J.M. Paper Models for Fullerenes C₆₀-C₈₄. *J. Chem. Educ.*, 1995, vol. 72, pp. 863 – 869.
- BONSON, K.; HEADRICK, R. L.; HAMMOND, D.; HAMBLIN, M. Working model of an atomic force microscope. *Am. J. Phys.*, 2011, vol. 79, pp. 189–192.
- BOO, W.O.J. An Introduction to Fullerene Structures: Geometry and Symmetry. *J. Chem. Educ.*, 1992, vol. 69, pp. 605 – 609.
- CAMPBELL, D. J.; OLSON, J. A.; CALDERON, C. E.; DOOLAN, P. W.; MENGELT, E. A.; ELLIS, A. B.; LISENSKY, G. C. Chemistry with Refrigerator Magnets: From Modeling of Nanoscale Characterization to Composite Fabrication. *J. Chem. Educ.*, 1999, vol. 76, pp. 1205–1211.



REFERENCES

- CAMPBELL, D. J.; MILLER, J. D.; BANNON, S. J. AND OBERMAIER, L.M. An Exploration of the Nanoworld with LEGO Bricks. *J. Chem. Educ.*, 2011, vol. 88, pp. 602–606.
- LORENZ, J. K.; OLSON, J. A; CAMPBELL, D. J.; LISENSKY, G. C. AND ELLIS, A. B. A Refrigerator Magnet Analog of Scanning-Probe Microscopy. *J. Chem. Educ.*, 1997, vol. 74, pp. 1032A–1032B.
- PLANINSIC, G.; LINDELL, A.; REMSKAR, M. Themes of nanoscience for the introductory physics course. *Eur. J. Phys.*, 2009, vol. 30, pp. S17–S31.
- CAMPBELL, D.; FREIDINGER, E.; QUERNS, M. *et al. Exploring the Nanoworld with LEGO® Bricks*. Peoria: Bradley University, 2012 [online] [accessed September 28, 2012]. Accessible at: <http://mrsec.wisc.edu/edetc/LEGO/index.html>
- TKÁČOVÁ, Z. *Nanoveda a nanotechnológie vo vyučovaní*. Bratislava: Metodicko-pedagogické centrum, 2011 [online] [accessed September 28, 2012]. Accessible at: <http://shared.mpc-edu.sk/web/OPSOSO%20z%20vyzvy%20na%20poziciu%20Odborny%20poradca%20vo%20vzdelavani/Nanoveda%20a%20nanotechnologie%20vo%20vyucovani.pdf>.
- KOLÁŘ, K.; MYŠKA, K.; HIRSCH, M. Fullereny a výuka organické chemie (3). *Biologie, chemie, zeměpis*, 1999, roč. 8, s. 177 – 178.
- PANÁČEK, A.; KVÍTEK, L.; KLEČKOVÁ, M. Koloidní chemie v praktických úlohách. *Chem. listy*, 2004, roč. 98, s. 39-41.
- PANÁČEK, A. a KVÍTEK, L. Praktické úlohy z koloidní chemie. *Chem. listy*, 2005, roč. 99, s. 606-609.
- HÁJKOVÁ Z. *Návrh implementace nových poznatků z interdisciplinárního oboru "nanotechnologie" do výuky přírodovědných předmětů na SŠ a příspěvek k edukaci studentů učitelství chemie v tomto oboru*. Praha: Univerzita Karlova, Přírodovědecká fakulta, Katedra učitelství a didaktiky chemie, 2011. Vedoucí rigorózní práce RNDr. Petr Šmejkal, Ph.D.
- HÁJKOVÁ, Z. a ŠMEJKAL, P. Vybrané demonstrace problematiky "nano" ve výuce chemie na SŠ. In *Alternativní metody výuky 2011*, sborník příspěvků, Gaudeamus, Hradec Králové, 2011. ISBN 978-80-7435-104-4.
- HÁJKOVÁ, Z. Models of carbon "nanoallotrope" C₆₀. In *Chemistry education – 2011*, conference proceedings. University of Latvia, 2011. ISBN 978-9984-45-421-4.
- HÁJKOVÁ, Z.; FEJFAR, A.; ŠMEJKAL, P. SPM at school: Seeing atoms is the best way to learn about them. *Chemické listy*, 2012, roč. 106, s. s927. ISSN 1803-2389.
- HÁJKOVÁ, Z. a ŠMEJKAL, P. Demonstrace „nano“ ve výuce přírodovědných předmětů na SŠ. In *Aktuálne trendy vo vyučovaní prírodných vied*. Trnava: Pedagogická fakulta Trnavskej univerzity v Trnave, 2012, s. 275 – 280. ISBN 978-80-8082-541-6.





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