CHEMISTRY EXPERIMENTS - FOR COMPARATIVE ANALYSES FOR DEMONSTRATING ENVIRONMENTAL DIFFERENCES ON VENUS, EARTH, MARS, AND TITAN - BUILT ON EDUCATIONAL SPACE PROBES HUNVEYOR AND HUSAR.

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Summary: We intended to compare environments of Venus, Earth, Mars and Titan by experiments planned for educational space probe landers and rovers (Hunveyor and Husar) built in Hungarian universities and high schools. The comparison of the chemistry of various materials in different planetary environments are exhibited by compositions, temperature, pressure of the atmospheres which result in diverse reactions different from the known terrestrial ones.

Introduction: Together with a course at Eötvös University where the comparative chemical reactions were demonstrated we planned to select some of them for space robots to realize them by simple robotics. The course focused on: 1) How planetary chemistry and research play role in activating students in their studies of classical experimental chemistry 2) How the well known reactions in terrestrial conditions may be extrapolated to another planets 3) The enthusiasm of students increases by those chemical experiments which demonstrate the differences between different planetary surfaces 4) Select chemical experiments to develop a new planetary robotics experiments to build them on the Hunveyor and Husar space probe models.

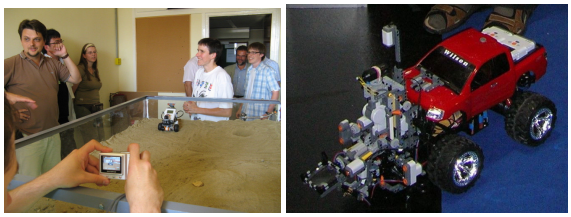

Fig. 1. Husar-5 test table demonstration and the rover with the solar heating experiment.

Experiments and demonstrations: There were two different groups. One for working on the space probe models to realize a simple experiment (Fig. 1.). The other for the course experiments (Fig. 2.). Personal discussions revealed how their intensely increased their affinity to chemistry.

Burning of metals in planetary atmospheres: To initiate planetary chemistry first the burning (oxidation) of metals is the most attractive reaction. The first metal was Mg. This metal burns both in oxygen rich terrestrial, CO_2 rich Martian and Venusian and nitrogen rich Titan atmospheres. However, the initiation needs preheating reaction. Terrestrial one: 2Mg (solid) + O_2 (gas) —> 2MgO (solid), Venusian and Martian one (carbon dioxide environment could be generated from dry ice): 2Mg (solid) + CO_2 (gas or solid) —> 2MgO (solid) + C (solid) and Titanian atmosphere, where combustion results in magnesium nitride: 3Mg (solid) + N_2 (gas) —> $2Mg_3N_2$ (solid) (Table 1.).

Fig. 2. A. Roka's atmospheric chemistry demonstrations.

Example: The precipitation experiment in the student course: In order to see the circulation sequence of the terrestrial and other planetary conditions and experiment is prepared with acetic acid. In the bottom of the retort the fluid acetic acid evaporates, however, on the top of the retort there is a dry ice containing test tube in the closing bung. The thermal gradient allows for the acetic acid to evaporate, precipitate in crystal needles on the test tube wall and drop back to the liquid in the bottom. (Fig. 2.) In a similar way the methane rains on Titan can be modeled if instead of dry ice liquid nitrogen is in the upper test tube.

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Table. 1. Comparison of the atmospheric chemical reactions for some planetary sized bodies

Table 1.	CO_2, N_2, (CO, SO_2) **Venus** **T (av) ca. +500 C**	N_2, O_2, (CO_2, H_2O, Ar) **Earth** **T (av) ca. +15 C**	CO_2, N_2, (Ar, O_2) **Mars** **T (av) ca. -63 C**	N_2, CH_4 **Titan** **T (av) ca. -180 C**
	p (av) ca. 9.2MPa	**p (av) ca.** 0.1 MPa	**p (av) ca.** 700-900 Pa	**p (av) ca.** 0.15 MPa
Mg burning	2 Mg + CO_2 (gas) ==> 2 MgO + C	2 Mg + O_2 (gas) ==> 2 MgO	2 Mg + CO_2 (gas/solid) ==> 2 MgO + C	3Mg + N_2 (gas) ==> Mg_3N_2
Na burning	4Na + 4 CO_2 (gas) = $Na_2C_2O_4$ + CO (gas) + Na_2CO_3	2Na + O_2 (gas) = Na_2O_2 Na + H_2O → = NaOH + ½ H_2	4Na + 4 CO_2 (gas/solid) = $Na_2C_2O_4$ + CO (gas) + Na_2CO_3	If O_2 is delivered by space probe and methane is used in a fuel cell, methanol can be produced +electricity p. After it, with methanol: $2CH_3OH + 2Na$ ==> $2CH_3ONa + H_2$;
Ca burning	2 Ca + CO_2 (gas) ==> 2 CaO + C	2 Ca + O_2 (gas) ==> 2 CaO	2 Ca + CO_2 (gas/solid) ==> 2 CaO + C	3Ca + N_2 (gas) ==> Ca_3N_2
Al burning	4 Al + $3CO_2$ (gas) ==> 2 Al_2O_3 + 3C	4 Al + $3O_2$ (gas) ==> 2 Al_2O_3	4 Al + $3CO_2$ (gas/solid) ==> 2 Al_2O_3 + 3C	2Al + N_2 (gas) ==> 2AlN
Gun-powder burning	burns	burns	burns	burns
KNO_3 ignition	KNO_3 ==> KNO_2 + ½O_2 decomposition only	KNO_3 ==> KNO_2 + ½O_2 decomposition only	KNO_3 ==> KNO_2 + ½O_2 decomposition only	KNO_3 ==> KNO_2 + ½O_2 $CH_4 + 2O_2 = CO_2 + 2H_2O$

Lyes or acids - pH measuring on Husar-5: There is a complex indicator of the chemistry in the planetary atmosphere: the Lavoisier cycle. Burning of metals in terrestrial atmosphere (Table 1.), results in lyes by the burning of nonmetals produce acids in the terrestrial conditions. The reaction between lyes and acids give salts. If such a cycle possible in a planetary atmosphere, then atmospheric weathering allows the exsolution of evaporites. As we know over terrestrial evaporates Mars also has such sedimentary layers on the surface. The Husar-5 rover first experiment [1] was the measuring of the pH of soil on the surface of a planetary body by using the classical indicator method.

Lacking water on Venus imply that the Lavoisier cycle type weathering did not produce in this way evaporate rocks on Venus. However, the reactions between metal-oxides and CO_2 can produce evaporites: on that way the L-cycle is a shorter process on Venus.

Summary: Focusing on comparative differences in chemistry in planetary environments and building some of these reactions as simple experiments on Hunveyor-Husar educational space probes made the program exciting and attractive for students. The overview and distinction of chemical processes, depending on the planetary *p, T*, composition environments helped students in selecting and building experiments for their Hunveyor and Husar experimental space probes [1-2].

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