Bioelectrochemically-assisted recovery of valuable resources from urine

L. Peixoto, S. G. Barbosa, A. ter Heijne, P. Kuntke, M.M. Alves, M.A. Pereira

CEB - Centre of Biological Engineering, Universidade do Minho, 4710-057 Braga, Portugal
Group: BRIDGE | Line: Environmental Biotechnology and Bioengineering

Source separated urine is highly concentrated in nutrients and biodegradable compounds. This work explores the potential of combining nutrient recovery from urine with simultaneous energy production in bioelectrochemical systems (BES), under the FP7 project "ValueFromUrine".
Non-spontaneous phosphorus (P) recovery by struvite precipitation was analysed by adding three different magnesium (Mg) sources (magnesium chloride ($MgCl_2$), magnesium hydroxide ($Mg(OH)^2$) and magnesium oxide (MgO)). A statistical design of experiments was used to evaluate the effect of Mg:P molar ratio (1:1, 1.5:1 and 2:1) combined with stirring speed (30, 45 and 60 rpm) for each Mg source tested. MgO at 2:1 molar ratio and a stirring speed of 30 rpm allowed to achieve the highest P recovery efficiency (99 %) with struvite crystals size of 50 to 100 µm [1].
Urine obtained after P recovery, showed high concentration of biodegradable compounds being subsequently fed as substrate in a microbial fuel cell (MFC). Microbial acclimation to urine was performed in a MFC resulting in an anaerobic community successfully enriched in "urine-degrading" electroactive microorganisms. When compared to the control assay operated without preliminary microbial enrichment (81±9 mA m^{-2}), the acclimation method achieved significantly higher current density (455 mA m^{-2}) ($p<0.05$). *Tissierella* and *Paenibacillus* were the dominant genus identified in the adapted microbial community. *Tissierella* can convert creatinine to acetate, whereas bacterial species belonging to the *Paenibacillus* genus are known to function as exoelectrogens. *Corynebacterium* that comprise urea-hydrolysing bacteria was also detected in the developed biofilms.
The potential of urine obtained after P recovery for energy production in a microbial electrolysis cell (MEC) was evaluated using three different carbon anode materials, phenol-based (Keynol), cellulose-based (C-TEX) and polyacrilonitrile-based (PAN). The MECs were inoculated using the previously acclimated microbial community. MEC using C-Tex generated the highest current density (904 mA m^{-2}), which was almost 3-fold higher than the MEC with Keynol (338 mA m^{-2}) and almost 8-fold higher than the MEC with PAN (118 mA m^{-2}) at an anode potential of -0.300 V vs. Ag/AgCl. The higher percentage of bacteria belonging to *Lactobacillales* and *Enterobacteriales* identified on C-Tex, suggest that microbes assigned to these orders were the responsible for the higher current generation.
In conclusion, this work contributed with new insights on the degradation of organics in urine, changes in anodic bacterial community and the effect of anode materials, aiming at improving anode performance on BES operating with urine.

References

[1] Barbosa, SG, Peixoto, L, Meulman, B, Alves, MM, Pereira, MA, A design of experiments to assess phosphorous removal and crystal properties in struvite precipitation of source separated urine using different Mg sources, Chemical Engineering Journal 298,146–153, 2016.