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A mini review: Optimal dye removal by Fenton process catalysed with waste materials

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Introduction

Textile industry has high demand in terms of water and chemical use. The unfixed dyes are a known problem in **textile effluents**, whose chemical structures widely differentiate.
Wastewater treatment is necessary to obtain an acceptable effluent quality for its discharge in the environment, thus contributing to industrial sustainability. Among biological and physicochemical treatments, **Fenton process** stands out between advanced oxidation processes as efficient in dye degradation. *Figure 1* shows dye degradation pathway through the heterogeneous Fenton reaction.
Various solid materials have been used as Fenton process catalysts, and they are divided on supported and non-supported ones.
To complete mineralize dye molecules, **optimization** of important process parameters (pH value, initial oxidant, catalyst and dye concentration, reaction time and temperature) is often needed. Their influence is commonly investigated through one-factor-at-a-time (OFAT) and response surface methodology (RSM).

Problem Description

The main focus of this study is on solid wastes that can be used beneficially in a heterogeneous Fenton treatment of colored wastewaters. Such application is an alternative to landfill disposal and promotes **industrial symbiosis**. Also, cost reduction of handling solid waste is reinforced and further value addition is boosted.

Methods

Optimization studies are based on screening experiments in order to determine which factors have the greatest (positive or negative) impact on Fenton process outcome.
The commonly used approach is **OFAT**, where one parameter influence is explored while all other significant process variables are kept constant. Statistical design of experiments (**RSM**) presents multivariate approach, where interaction effect between variables is easier to study and determine (*Figure 2*).

Results and discussion

The **waste management** focus is to control and decrease waste and non-wanted by-products generation. General end-of-life practices are waste collecting and sorting, and if possible materials are recovered.
Presented studies in *Figure 3* are based on OFAT methodology with catalysts from different burning and casting processes. Investigation of diazo dye removal in photo-Fenton process was catalysed with fly ash and foundry sand. Low initial H_2O_2 and fly ash concentration were needed to significantly degrade dye molecules in short time, due to a higher Al content.

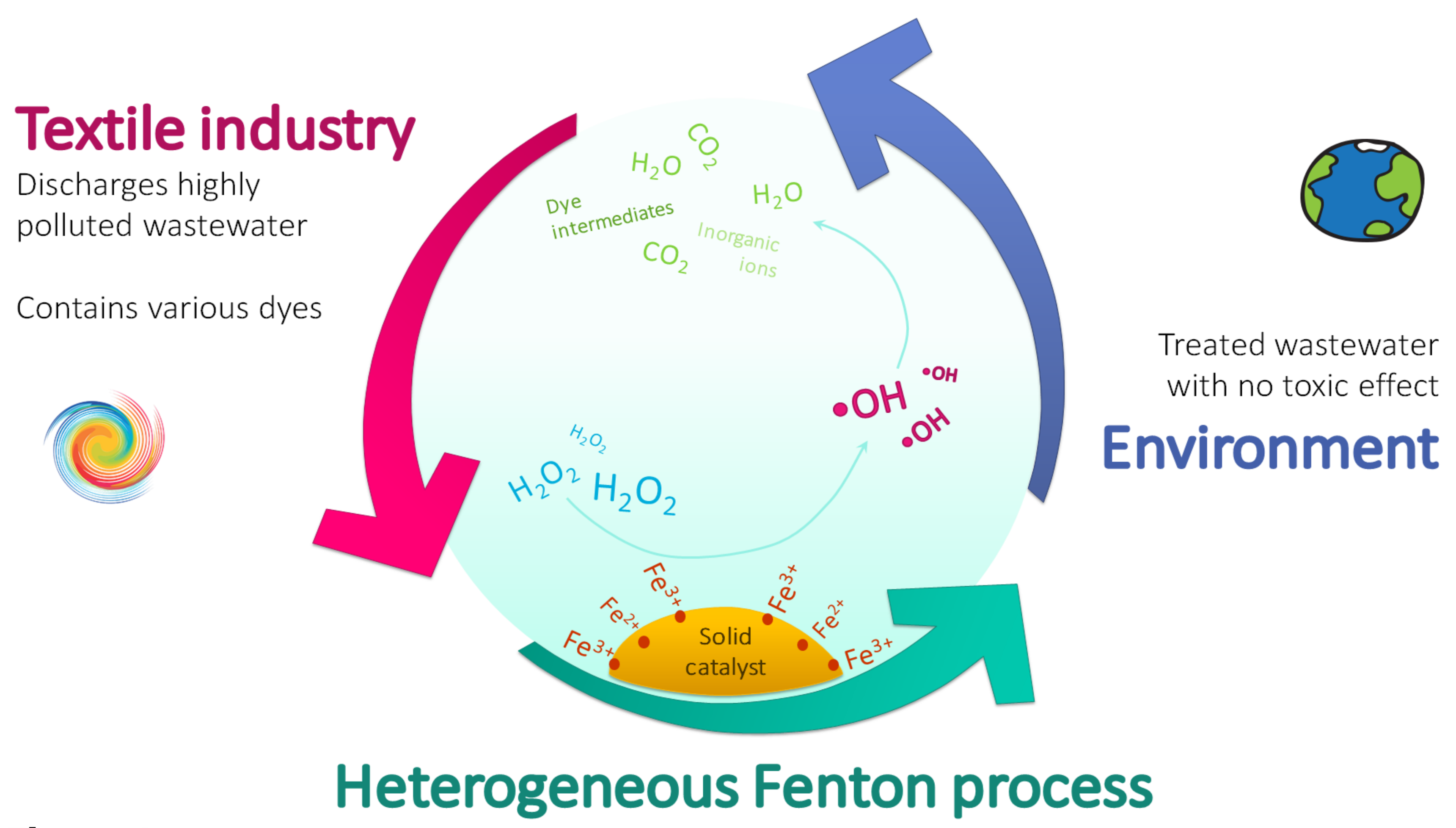

Figure 1.
Simplified heterogeneous Fenton reaction mechanism and the main environmental problem of the textile industry

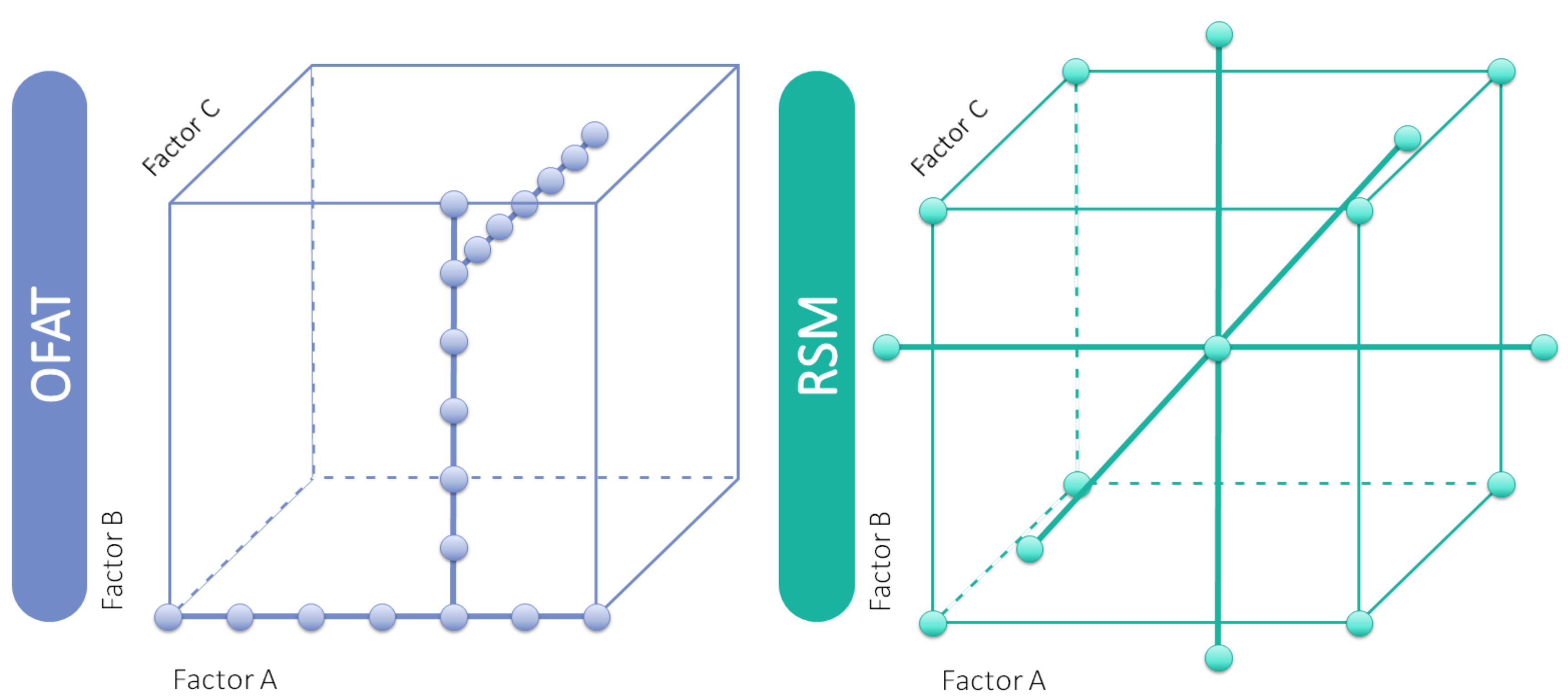

Figure 2.
Visual differences in explored design space with OFAT and RSM methodology

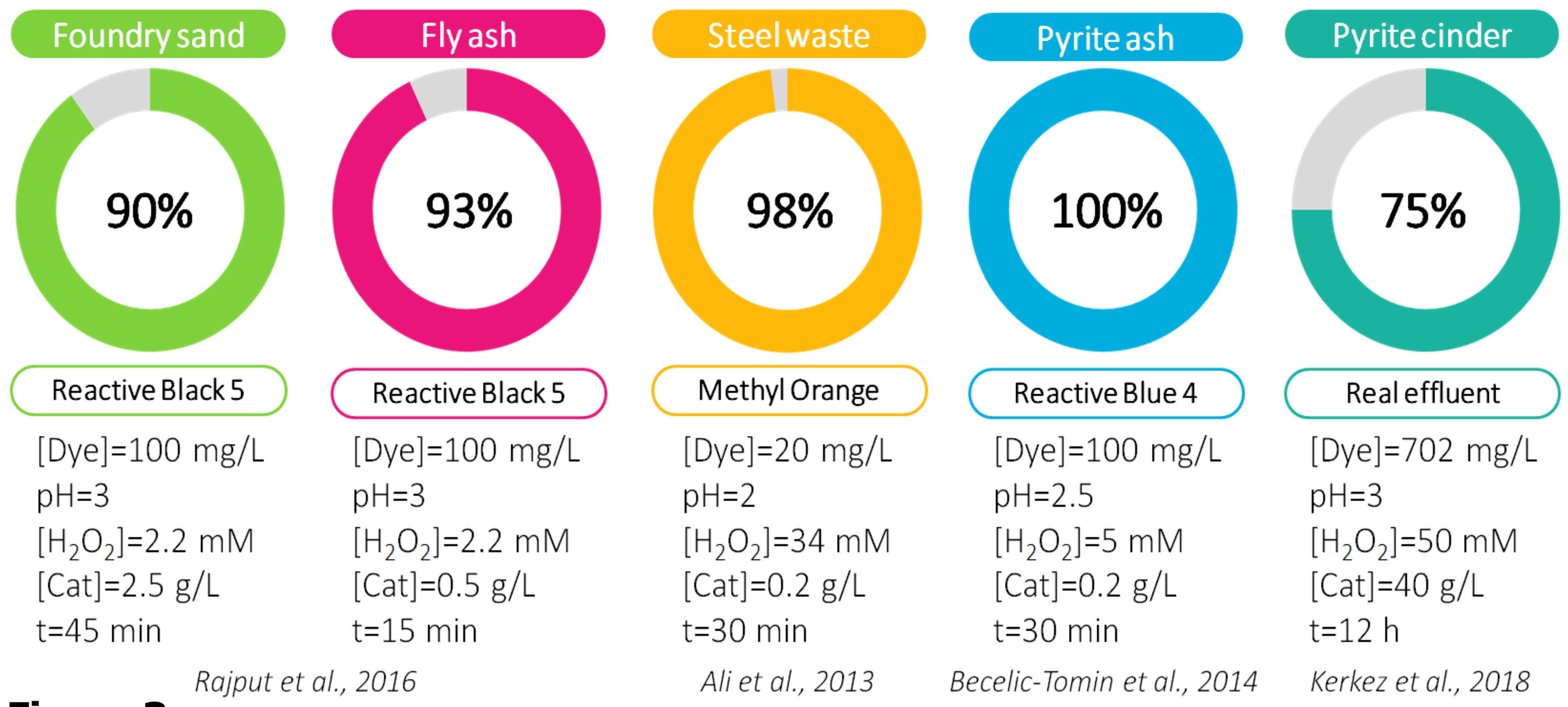

Figure 3.
OFAT optimal conditions achieved with industrial waste catalysed Fenton process

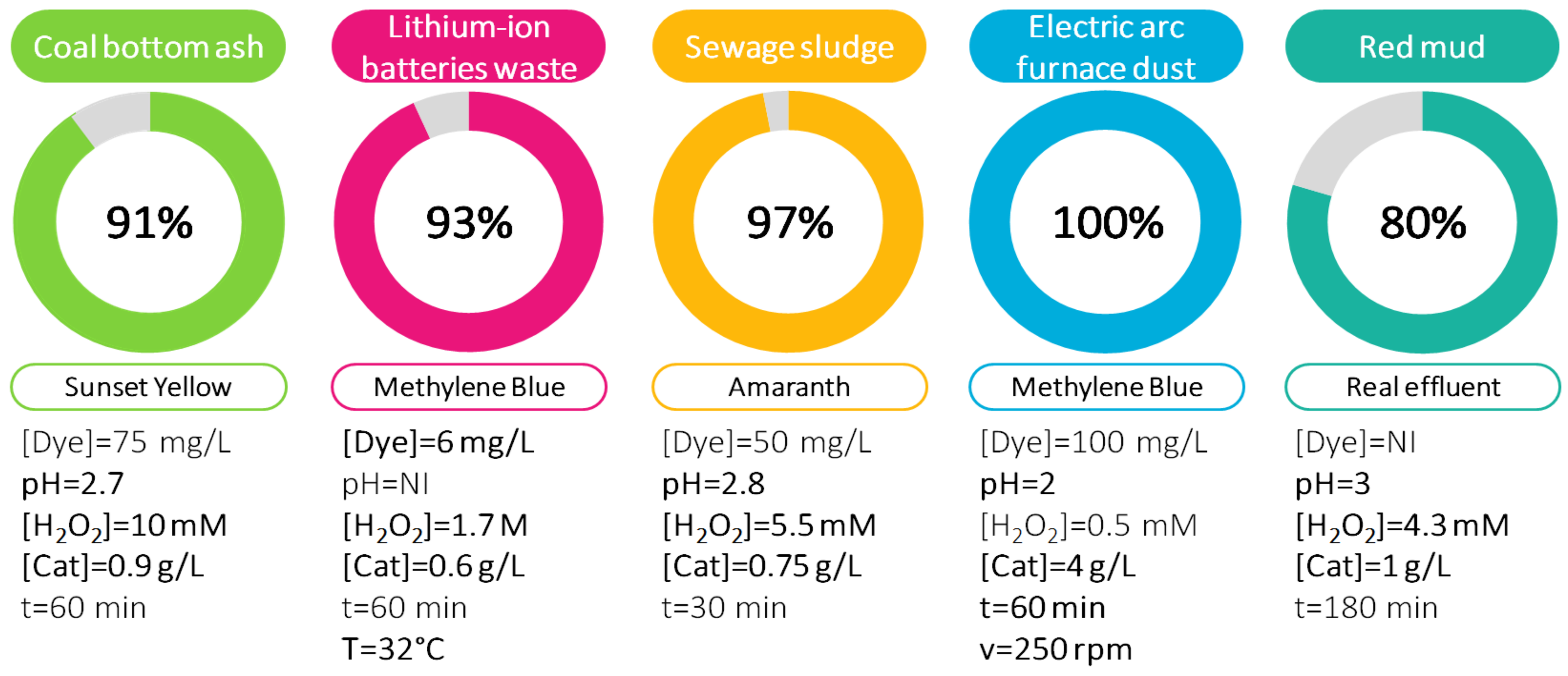

Figure 4.
RSM optimal conditions achieved with industrial waste catalysed Fenton process;
*NI-not included

When comaparing to foundry sand lower activity was detected. The steel industry waste had magnetic properties which provided easy removal after azo dye treatment, but high oxidant dose was needed. Anthraquinone dye was completely degraded with pyrite ash. Acidic Fenton conditions lead to high heavy metals leaching, where additional step after heterogeneous process was needed. Likewise, the obtained removal of six dyes mixture was satisfactory, but Pb, Cu, Cr and Cd were leached from pyrite cinder after real textile effluent treatment.
RSM (CCD) based studies are shown in *Figure 4*. 91% azo dye was degraded in photo-Fenton process catalysed with coal bottom ash (rich in Al_2O_3 and SiO_2). This material is commonly disposed with no commercial value. Catalyst from discarded mobile phone lithium-ion batteries was efficient in thiazine dye removal, with extremely high oxidant demand. Thermally treated Al-rich sewage sludge in photo/Fenton achieved notable efficiency. High load of Co impregnated electric arc furnace dust and low H_2O_2 were sufficient to completely degrade thiazine dye. 80% decolorization of real textile effluent was achieved in the heterogeneous Fenton process catalysed with waste red mud.

Conclusion

The aim of this mini review is to give insight on the various waste materials use as Fenton reaction catalysts for dye removal. It was revealed that catalyst concentration, oxidant concentration, pH value, dye concentration and reaction time are main factors that influence final decolorization efficiency. Reported materials showed great potential thus reinforcing their value addition and possible future industrial symbiosis. In order to obtain fully sustainable waste management, further catalyst stability studies has to be done.

REFERENCES

Ali, M. et al., 2013, *Appl. Water Sci.* **3**, doi: 10.1007/s13201-013-0078-1
Becelic-Tomin, M. et al., 2014, *Sci. World J.* **234654**, doi: 10.1155/2014/234654
de Matos Vargas, A.M. et al., 2019, *J. Environ. Chem. Eng.* **7**, doi: 10.1016/j.jece.2019.103191
Drumm, F.C. et al., 2019, *Water Air Soil Pollut.* **230**, doi: 10.1007/s11270-019-4327-2
Grassi, P. et al., 2020, *Environ. Technol. Innov.* **17**, doi: 10.1016/j.eti.2019.100544
Kerkez, Đ. et al., 2018, Proceedings of 9th GRID, Novi Sad
Kulić, A. et al., 2018, Proceedings of 9th GRID, Novi Sad
Maleki Rizi, M.H. et al., 2019, *Int. J. Environ. Sci. Technol.* **16**, doi: 10.1007/s13762-017-1579-5
Rajput, H. et al., 2016, *J. Environ. Eng. Landsc. Manag* **24(01)**, doi: 10.3846/16486897.2015.1109517

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