



Universidade do Minho  
Escola de Engenharia

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### INTELLIGENT POLYMER FOR WATER TREATMENT

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#### INTRODUCTION

The use of fertilizers to allow a rapidly replace of nutrient levels in soil, after crops harvested have being a common practice since ancient times as response to the global food necessities. Demonstrated in the middle of 19<sup>th</sup> century, phosphorus element is the limiting grow nutrient for most part of crops. The phosphorus removed from soil by crops was replaced using waste products as manure, crop residues and human excretas, via regular flooding's or shift cultivation, however with increase of food demand these technics were no more sustainable. The search for news sources of phosphorus led to the mineralization of phosphorus rock to be use as fertilizer (Schröder et al, 2009).

Nevertheless, the massive in put of phosphorus in agriculture land have been contributing for natural stress observed on aquatic bodies and surrounding wetlands. As a result of this excessive nutrient enrichment, an excessive growth algae has been observed. This phenomenon is describe as eutrophication. The eutrophication of natural surface waters impairs their use for recreational and domestic consumption and limit their use by native biota. Thus, the reduce of phosphorus in eutrophic waters becomes an imperative task. It is known, that phosphorus adsorbed onto iron and aluminun oxides and clays. The must common method use to adsorbed phosphorus consisted on the direct application of these agents. This type of approach has disadvantage, for example, isn't possible to recover the applied agent, which can increased. Moreover, being the phosphorus rock a non-renewable source, with depletion predictions of world reserves ranging from 50 years (Steen 1998) in the worst case to recent estimates of 400 years (IFDC 2010), the recover and recycling of this is essential.

The present work investigated the removal of phosphate from water using a new developed hybrid nanocomposite containing aluminium nanoparticles

(HPN). Organic-inorganic hybrids have been increasing the academic interest, due to its unique properties. The combination of organic and inorganic structures at molecular level forms a nanocomposite, with enhanced properties. These could not be achieved by other materials, opening this away new windows of applications. The HPN results from a reaction between an organic and an inorganic component, being the latter the removal agent for phosphorus. HPN was obtained by a sol gel process, which consists in the mixing of a polymer in the molten state with an aluminium precursor. The chosen polymer was polypropylene grafted with maleic anhydride (PP-g-MA).

The chemical structure and the physical properties of the prepared HPN were characterized using several techniques. Using this approach it was possible to develop a new material with the required properties. The experiments done in the present study comprised short-term batch tests to compare the P removal rates of the HPN with that of other materials and column experiments to assess the long-term attenuation capacity of the HPN under conditions of continuous P loadings.

#### RESULTS

The FT-IR spectrum of HPN is presented in Figure 1. Analysing the FT-IR spectra two new bands appear, confirming that Al-O bonds were formed as a result of chemical reaction between MA groups and aluminum precursor, moreover the spectrum confirmed the formation of Al-OH group.



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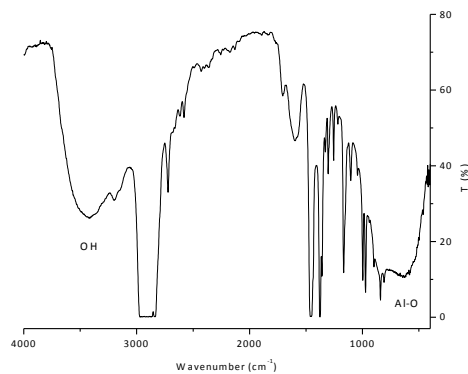


Figure 1 – FT-IR spectrum of HPN.

The kinetic curve of phosphorus removal by HPN are depicted in Figure 2. The phosphate removal capacity was  $0.80 \pm 0.01$  mg/g for HPN. Bauxite and shale, both argillaceous rocks, presented a phosphate removal capacity of the same order of magnitude of HPN, 0.36 mg/g and 0.73 mg/g respectively. Previous studies showed that activated alumina, which is pure  $\text{Al}_2\text{O}_3$ , presented a phosphate removal capacity of 7 mg/g. However, when comparing the phosphate removal capacity of HPN with other aluminum based materials described in literature, we need to keep in mind that only a fraction of the HPN is active in removing phosphate (lower than 25%).

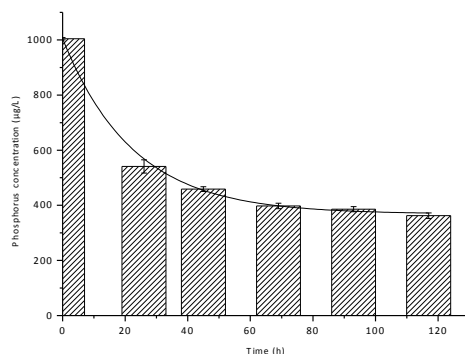


Figure 2 – Phosphate concentration profile for HPN.

The removal of phosphate in a packed bed column with HPN along 30 d is depicted in Figure 3. The residence time ( $T$ ) determined was around 29 min. The removal efficiency of phosphate was 100 % during the first 40 h of operation. It decreased to 50 % at the end of 134 h,

and the column reached complete saturation at 500 h. The column removal capacity determined was 0.67 mg/g, which was lower than that obtained in batch essays. This result might be explained by the difficulty to promote the contact between the HPN and the phosphate solution because the HPN is a hydrophobic material.

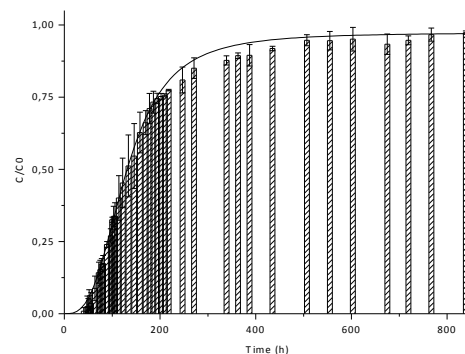


Figure 3 - Relative phosphate concentration ( $C/C_0$ ) at the effluent of a column as a function of time for HPN.

### CONCLUSION

The developed HPN shown to be efficient on phosphate removal, being possible use it as remediation tool in impair eutrophic waters.

### REFERENCES

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### AUTHORS' BIOGRAPHIES

**Manuel Oliveira** went to Minho University to study Chemistry – Quality Control and obtained his degree in 2006. After, he worked on water treatment during two years, he started the PhD on the same subject in 2008.

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