



Short Communication

Fate of Chemical Activators in The Aqueous Environment: What Should We Do About It?

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Introduction

Activated carbon is widely used in removing the pollutants from air and water. It is a rich carbon material with unique porous textures and surface properties that enable the desired pollutants to be captured (Marsh and Rodriguez-Reinoso, 2006). Activated carbon can be prepared using carbonaceous precursors via two methods, namely physical activation and chemical activation. The physical activation employs oxidizing gas such as CO₂, steam or a mixture of both to manufacture the pores within the materials, while chemical activation utilizes the chemical activators to perform the job. It is indisputable that the activated carbon prepared via chemical activation offers higher yield at lower activation temperature with higher specific surface area than that through physical activation. Zinc chloride and potassium hydroxide are among the commonly used chemical activators for activated carbon (Marsh and Rodriguez-Reinoso, 2006; Heidari *et al.*, 2014). In chemical activation, the carbonaceous material is first impregnated with the chemical activator prior to activation under anoxic environment or inert gas at temperatures between 400 and 600°C. Upon which, the resultant activated carbon is soaked in dilute hydrochloric acid for demineralization, and thereafter is washed with distilled water to a constant pH (Heidari *et al.*, 2014; Zaini *et al.*, 2009).

It is noteworthy that the use of hydrochloric acid is also meant to get rid of the residual activator remained on activated carbon as the activation is commonly done at temperature below the boiling point of the activator. Thus, it is likely that some fraction of the activator is still remain within the carbon matrix. The aforementioned washing step is important so that the removal of desired pollutants is not interrupted by the compromised performance of activated carbon because of the partially clogged pores. However, the release of activator may also introduce the secondary pollution to the wash stream and the effluent being treated. Finding an immediate solution to this predicament is a challenging task that requires one to consider the quality and performance of activated carbon, as well as the implications to the aquatic environment. Therefore, this commentary paper is aimed at discussing the fate of chemical activators to the water bodies, and providing some useful insight on how the impacts to the environment can be minimized.

Current scenario – the dilemma

If soaking and rinsing the activated carbon preceding its utilization for environmental protection is imperative, therefore it indirectly infers an inevitable release of certain amount of activators to the environment. It is well understood that most of the activators used in the preparation of activated carbon are highly toxic and could bring bad implications to the environment and public health. Water becomes polluted, and thus jeopardize the aquatic creatures therein. Table 1 summarizes the implications of the commonly used activators to the environment. So, what should we do about it? Activated carbon is important for the environmental protection, and so the environment itself that is inadvertently polluted

through the use of activators in the preparation of activated carbon. Therefore, there is a need for firm and balance solutions for such a trade-off.

Table 1. The commonly used activators of activated carbon and their environmental implications

Activator	Melting point (°C)	Boiling point (°C)	Implication to the aqueous environment
Zinc chloride	292	756	Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment; less toxic degradation products
Potassium hydroxide	406	1327	Poisonous and harmful chemical, breeding of mosquito fish in 80 mg/L for 24 hours; less toxic degradation products

Future challenges

There are few options that can be put into practice. Finding the less toxic activators for activated carbon could be one of the promising alternatives. Practically, using the less harmful chemicals would contribute little implications to the environment. Some of the possible candidates are sodium chloride (Okeola *et al.*, 2012) and potassium chloride (Wang *et al.*, 2009). Yet, this may sound not too attractive, as their role as activator is still lack in wide literature. Moreover, the quality of activated carbon produced could be of substandard as compared to the one prepared using the commonly used activators. On the other hand, it paves the way for further investigation to establish the textural characteristics and adsorptive performance of activated carbon by the so-called non-traditional activators. Using the composite of activators, and combining the two activation strategies may also become a subject of considerable interest. The outcomes of which would shed some light towards the minimization of toxic chemicals in the preparation of activated carbon.

To reuse the rinsed activator (wash liquid) from the activated carbon is another option to be considered. Through this approach, the release of activator to the water bodies can be avoided. It can be done by using the soxhlet-type heating mode, in which the activated carbon is immersed in the boiled washed water and the step is repeated several times to recover the activator. In addition, the amount of water to be used in recovering the activator can be pre-determined for subsequent activation. Necessary design would be required to accommodate the activated carbon for large scale production. Such capital costs would be regarded as the investment for the betterment of future sustainability. Even though the boiling point of the activators are higher than the operating temperature, it is believed that some portion of the activator used in the activation is eventually vaporized or melted and become intercalated within the carbon matrix. Therefore, it is nearly impossible to recover the same amount of activator used in the preceding activation. Nevertheless, good porous carbon but with somewhat smaller specific surface area is still can be prepared using the recovered activator (Zaini *et al.*, 2014). It was tested for the same target pollutant and showed a slightly lower removal performance per unit mass (Zaini *et al.*, 2014). Depending on the textural properties, the resultant activated carbon could also be tested to capture other kinds of pollutants and perhaps to be employed for other specific applications.

Conclusion

With these views, the released of toxic activators to the water bodies could be greatly minimized, if not totally avoided. Less toxic activators and small capital investment to the activated carbon production line would really help to preserve the environment from the foreseeable release of the harmful and toxic activators.

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References

- Heidari, A., Younesi, H., Rashidi, A. and Ghoreyshi, A. 2014. Adsorptive removal of CO₂ on highly microporous activated carbons prepared from *Eucalyptus camaldulensis* wood: Effect of chemical activation. *Journal of the Taiwan Institute of Chemical Engineers*, 45(2): 579-588.
- Marsh, H. and Rodriguez-Reinoso, F. 2006. *Activated Carbon*. Elsevier, Amsterdam.
- Okeola, O.F., Odebunmi, E.O. and Ameen, O.M. 2012. Comparison of sorption capacity and surface area of activated carbon prepared from *Jatropha Curcas* fruit pericarp and seed coat. *Bulletin of the Chemical Society of Ethiopia*, 26(2): 171-180.
- Wang, X., Zhu, N., Xu, J. and Yin, B. 2009. Preparation of activated carbons from wet activated sludge by direct chemical activation. *Water Science and Technology*, 59(12): 2387-2394.
- Zaini, M.A.A., Okayama, R. and Machida, M. 2009. Adsorption of aqueous metal ions on cattle-manure-compost based activated carbons. *Journal of Hazardous Materials*, 170(2-3): 1119-1124.
- Zaini, M.A.A., Wee-Meng, T., Kamaruddin, M.J., Mohd-Setapar, S.H. and Che-Yunus, M.A. 2014. Microwave-induced zinc chloride activated palm kernel shell for dye removal. *Sains Malaysiana*, 43(9): 1421-1428.