Mixture toxicity of zinc oxide nanoparticle and chemicals with different mode of action upon *Vibrio fischeri*

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Abstract

Background: Zinc oxide nanoparticle (*n*ZnO) and chemicals with different mode of action (MOA, i.e., narcotic and reactive) were frequently detected in the Yangtze River. Organisms are typically exposed to mixtures of *n*ZnO and other chemicals rather than individual *n*ZnO. Toxicity of *n*ZnO is caused by the dissolution of Zn^{2+}, which has been proved in the field of single toxicity. However, it is still unclear whether the released Zn^{2+} plays a critical role in the *n*ZnO toxicity of *n*ZnO-chemicals mixtures. In the present study, the binary mixture toxicity of *n*ZnO/Zn^{2+} and chemicals with different MOA was investigated in acute (15 min) and chronic (12 h) toxicity test upon *Vibrio fischeri* (*V. fischeri*). The joint effects of *n*ZnO and tested chemicals were explored. Moreover, two classic models, concentration addition (CA) and independent action (IA) were applied to predict the toxicity of mixtures.

Results: The difference of toxicity unit (TU) values between the mixtures of Zn^{2+}-chemicals with those of *n*ZnO-chemicals was not significant ($P > 0.05$), not only in acute toxicity test but also in chronic toxicity test. The antagonistic or additive effects for *n*ZnO-chemicals can be observed in most mixtures, with the TU values ranging from 0.75-1.77 and 0.47-2.45 in acute toxicity test and chronic test, respectively. We also observed that the prediction accuracy of CA and IA models was not very well in the mixtures where the difference between the toxicity ratios of the components was small (less than about 10), with the mean absolute percentage error (MAPE) values ranging from 0.14-0.67 for CA model and 0.17-0.51 for IA model, respectively.

Conclusion: We found that the dissolved Zn^{2+} mainly accounted for the *n*ZnO toxicity in the mixtures of *n*ZnO-chemicals, and the joint effects of these mixtures were mostly antagonism and additivity. CA and IA models were unsuitable for predicting the mixture toxicity of *n*ZnO-chemicals at their equitoxic ratios.

Full-text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

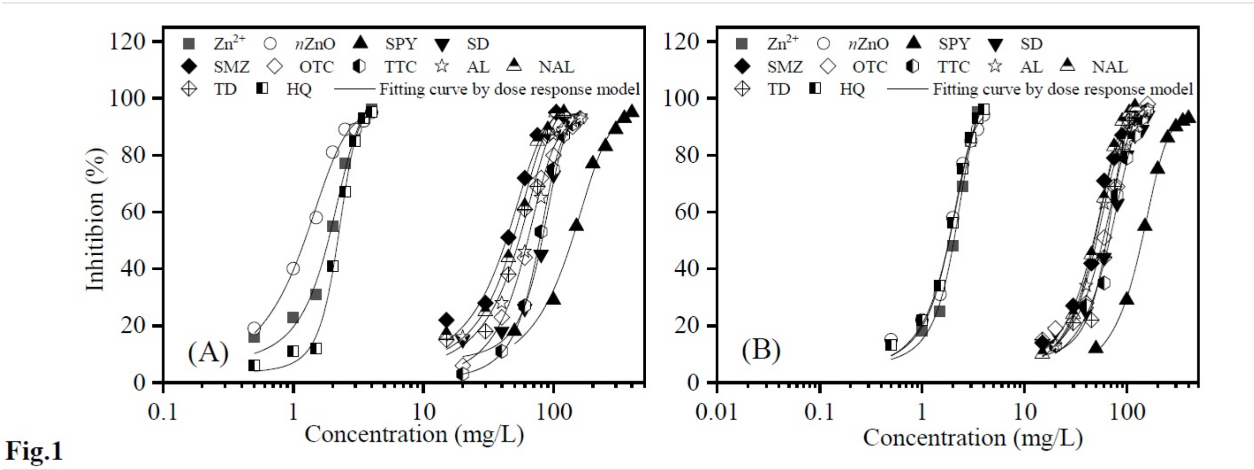

Figure 1

The single toxic effects of chemicals upon V. fischeri and the fitted dose response curves.

(A) The acute toxicity test results, (B) the chronic toxicity test results

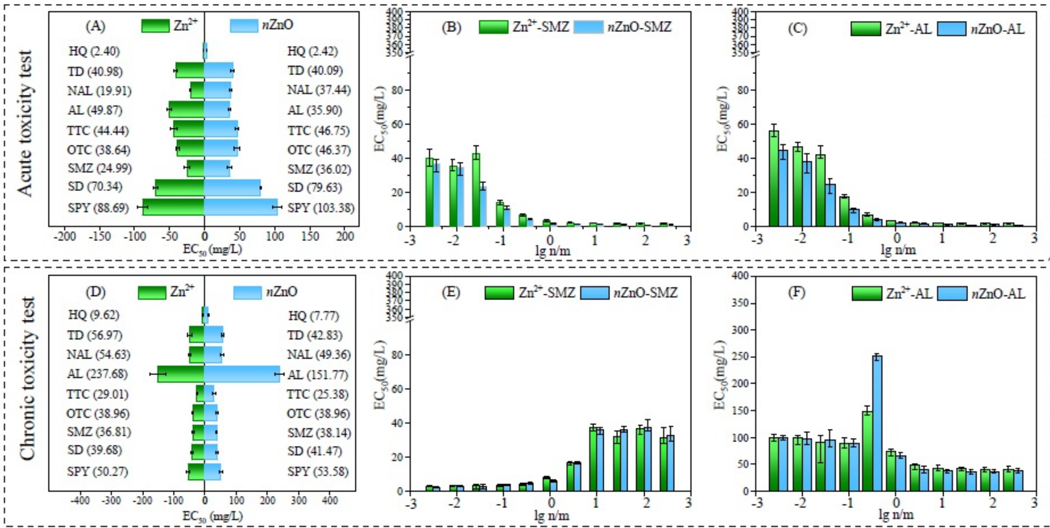

Fig. 2

Figure 2

Comparison of mixture toxicity between Zn2+-chemicals with nZnO-chemicals. (A) Zn2+-chemicals and nZnO-chemicals at equitoxic ratios in acute test, (B) Zn2+-SMZ and nZnO-SMZ at non-equitoxic ratios in acute test, (C) Zn2+-AL and nZnO-AL at non-equitoxic ratios in acute test, (D) Zn2+-chemicals and nZnO-chemicals at equitoxic ratios in chronic test, (E) Zn2+-SMZ and nZnO-SMZ at non-equitoxic ratios in chronic test, (F) Zn2+-AL and nZnO-AL at non-equitoxic ratios in chronic test

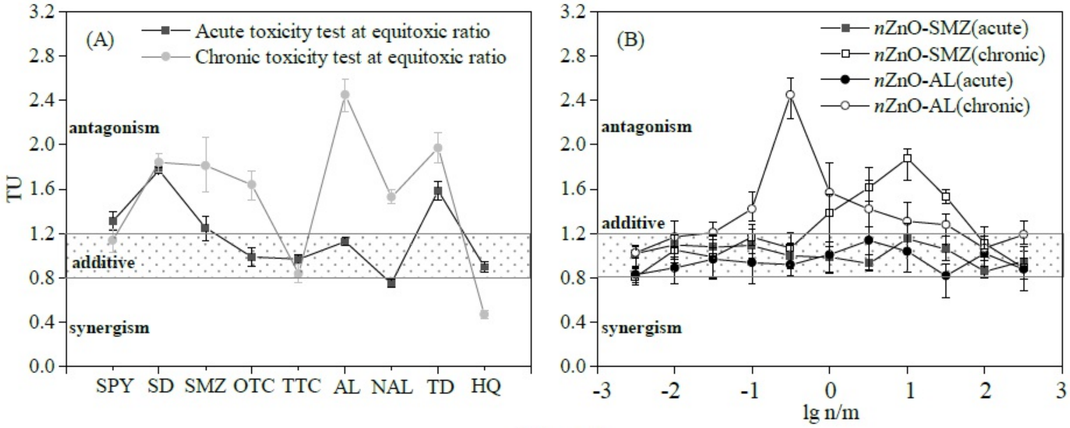

Fig. 3

Figure 3

Joint effects of nZnO-chemicals at equitoxic ratios (A) and at non-equitoxic ratios (B)

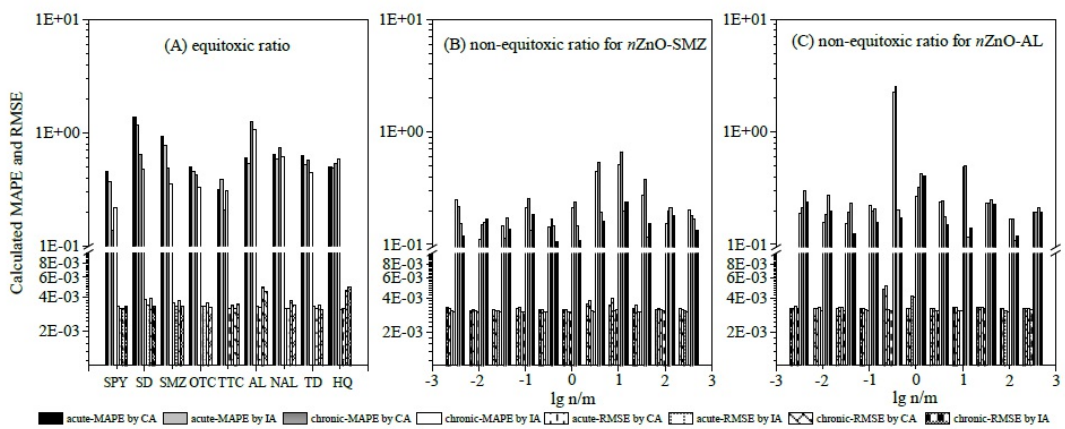

Fig. 4

Figure 4

The results of MAPE and RMSE values for CA and IA models from binary mixtures. (A) nZnO-9 chemicals at equitoxic ratios, (B) nZnO-SMZ at non-equitoxic ratios, (C) nZnO-AL at non-equitoxic ratios

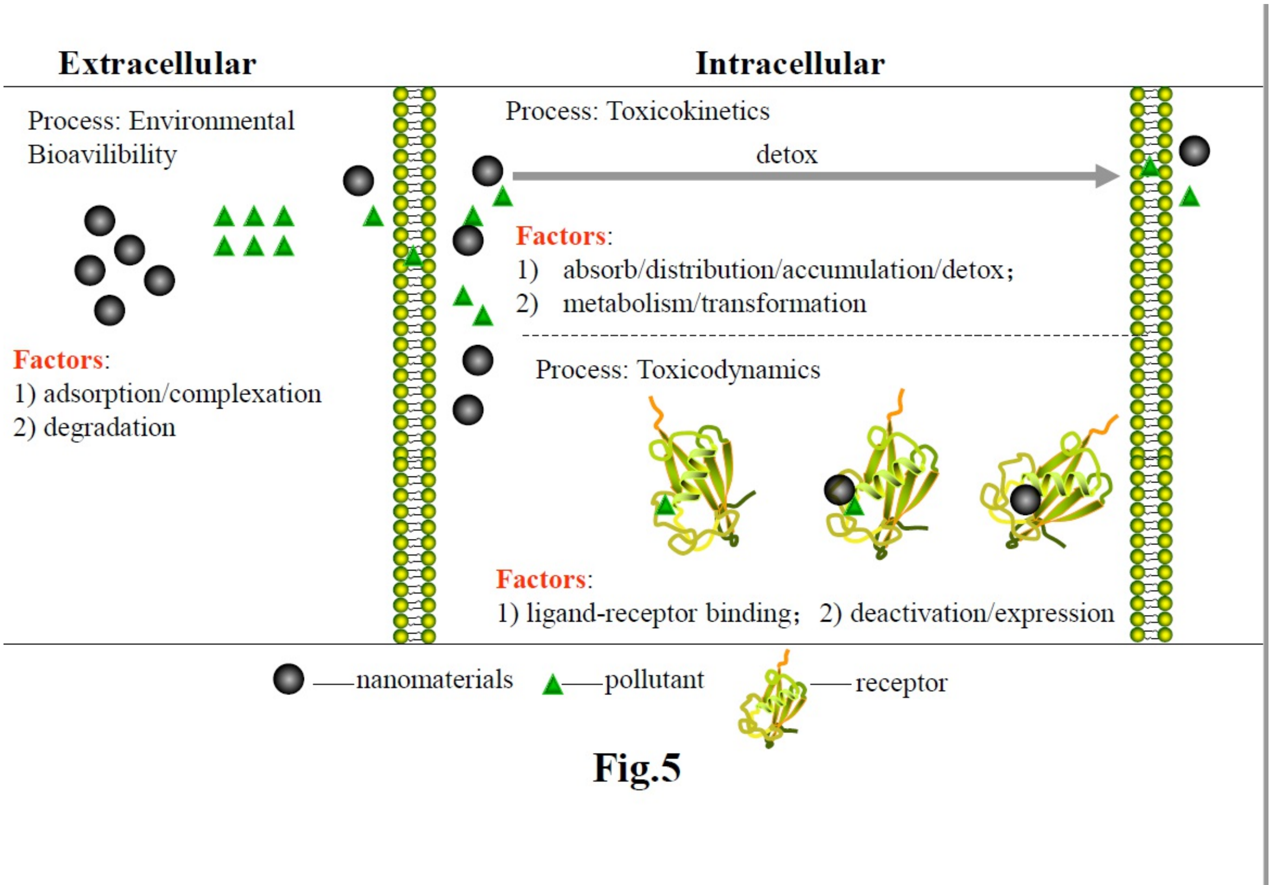

Figure 5

The mechanisms underlying the toxicities of NMs and pollutant

Supplementary Files

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