## **Supporting Information**

## Characterization of Dialkyldithiophosphates as Slow Hydrogen Sulfide Releasing Chemicals and Their Effect on the Growth of Maize

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The NMR tubes for samples to analyze by <sup>31</sup>P NMR spectroscopy did not have an internal standard to reference the spectra. The typical internal standard is phosphoric acid and since our chemicals degrade to release phosphoric acid we did not want it present in the NMR spectra. We also did not know where our new peaks would appear, so no standard was used. The NMR instrument was regularly checked for drift using a <sup>31</sup>P reference. The chemical shift of the peaks was consistent and did not significantly vary from spectra to spectra.



**Figure S1.** The <sup>31</sup>P NMR spectrum of the protonated acid of dibutyldithiophosphate showed 35% hydrolyzed after 41 days in a vial at room temperature. The percent of hydrolysis was found by integrating the peak for dibutyldithiophosphate at 111.85 ppm and the peaks for the hydrolyzed products at 85.83 and 56.87 ppm.



**Figure S2.** The <sup>31</sup>P NMR spectrum of the ammonium salt of dibutyldithiophosphate showed no hydrolysis after 41 days in a vial at room temperature.



**Figure S3.** The <sup>31</sup>P NMR spectrum of dibutyldithiophosphate stored in CDCl<sub>3</sub> for 29 days showed 15% of it hydrolyzed.



**Figure S4.** Phosphoric acid was confirmed by allowing dibutyldithiophosphate to degrade in  $H_2O$  at 85 °C until the suspected phosphoric acid peak in the <sup>31</sup>P NMR spectrum was observed (left). Phosphoric acid was added to the NMR tube and the <sup>31</sup>P NMR spectrum showed an increase in intensity of the lone peak.



**Figure S5.** To confirm phosphoric acid could be converted to chemical B from Figure 3, 20 equivalents of *n*-butanol was added to phosphoric acid in water. The mixture was heated at 85 °C for 97 days and a new peak in the <sup>31</sup>P NMR spectrum at -0.31 ppm corresponding to chemical B appeared. This new peak was a pentent similar to chemical B. This experiment was not buffered casing a slight shift in chemical shift of the peaks for phosphoric acid and chemical B.



**Figure S6.** Chemical C was isolated and confirmed using a) <sup>31</sup>P NMR spectroscopy, b) <sup>1</sup>H NMR spectroscopy, c) <sup>13</sup>C NMR spectroscopy, and high resolution mass spectrometry. The solvent used was D<sub>2</sub>O. The calculated HRMS for  $C_7H_8O_2PS_2$  is 218.97034 and the measured value was 218.9682.



**Figure S7.** The concentration of  $H_2S$  from an aqueous solution of 0.25 M dioctyldithiophosphate ammonium salt is shown. The concentration of  $H_2S$  was measured using an  $H_2S$  sensitive electrode. This chemical was mostly insoluble and did not release a measurable amount of  $H_2S$ .



**Figure S8.** The concentration of  $H_2S$  from an aqueous solution of 0.25 M didodecyldithiophosphate ammonium salt is shown. The concentration of  $H_2S$  was measured using an  $H_2S$  sensitive electrode. This chemical was mostly insoluble and did not release a



measurable amount of H<sub>2</sub>S.

Figure S9. <sup>1</sup>H NMR spectrum of dibutyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S10. <sup>31</sup>P NMR spectrum of dibutyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S11. <sup>13</sup>C NMR spectrum of dibutyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S12. <sup>1</sup>H NMR spectrum of dibutyldithiophosphate in CDCl<sub>3</sub>.



Figure S13. <sup>31</sup>P NMR spectrum of dibutyldithiophosphate in CDCl<sub>3</sub>.



Figure S14. <sup>13</sup>C NMR spectrum of dibutyldithiophosphate in CDCl<sub>3</sub>.



Figure S15. <sup>1</sup>H NMR spectrum of dihexyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S16. <sup>31</sup>P NMR spectrum of dihexyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S17. <sup>13</sup>C NMR spectrum of dihexyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S18. <sup>1</sup>H NMR spectrum of dioctyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S19. <sup>31</sup>P NMR spectrum of dioctyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S20. <sup>13</sup>C NMR spectrum of dioctyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S21. <sup>1</sup>H NMR spectrum of didecyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S22. <sup>31</sup>P NMR spectrum of didecyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S23. <sup>13</sup>C NMR spectrum of didecyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S24. <sup>1</sup>H NMR spectrum of didodecyldithiophosphate ammonium salt in CDCl<sub>3</sub>.



Figure S25. <sup>31</sup>P NMR spectrum of didodecyldithiophosphate ammonium salt in CDCl<sub>3</sub>.

![](_page_14_Figure_0.jpeg)

Figure S26. <sup>13</sup>C NMR spectrum of didodecyldithiophosphate ammonium salt in CDCl<sub>3</sub>.

![](_page_14_Figure_2.jpeg)

Figure S27. <sup>1</sup>H NMR spectrum of diethyldithiophosphate ammonium salt in D<sub>2</sub>O.

![](_page_15_Figure_0.jpeg)

Figure S28. <sup>31</sup>P NMR spectrum of diethyldithiophosphate ammonium salt in D<sub>2</sub>O.

![](_page_15_Figure_2.jpeg)

**Figure S29.** <sup>13</sup>C NMR spectrum of diethyldithiophosphate ammonium salt in D<sub>2</sub>O.

The corn plants were harvested by cutting level to the soil as shown in Figure S30.

![](_page_16_Picture_1.jpeg)

**Figure S30.** The potted corn plants are shown. The red arrow indicates where the plants were cut before their weights were measured.