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Microfabricated Nitrogen-Phosphorus Detector (µNPD)
Determination of Sensitivity and Selectivity

Uncoated NPD device (cantilever device) next to a dime.

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Abstract

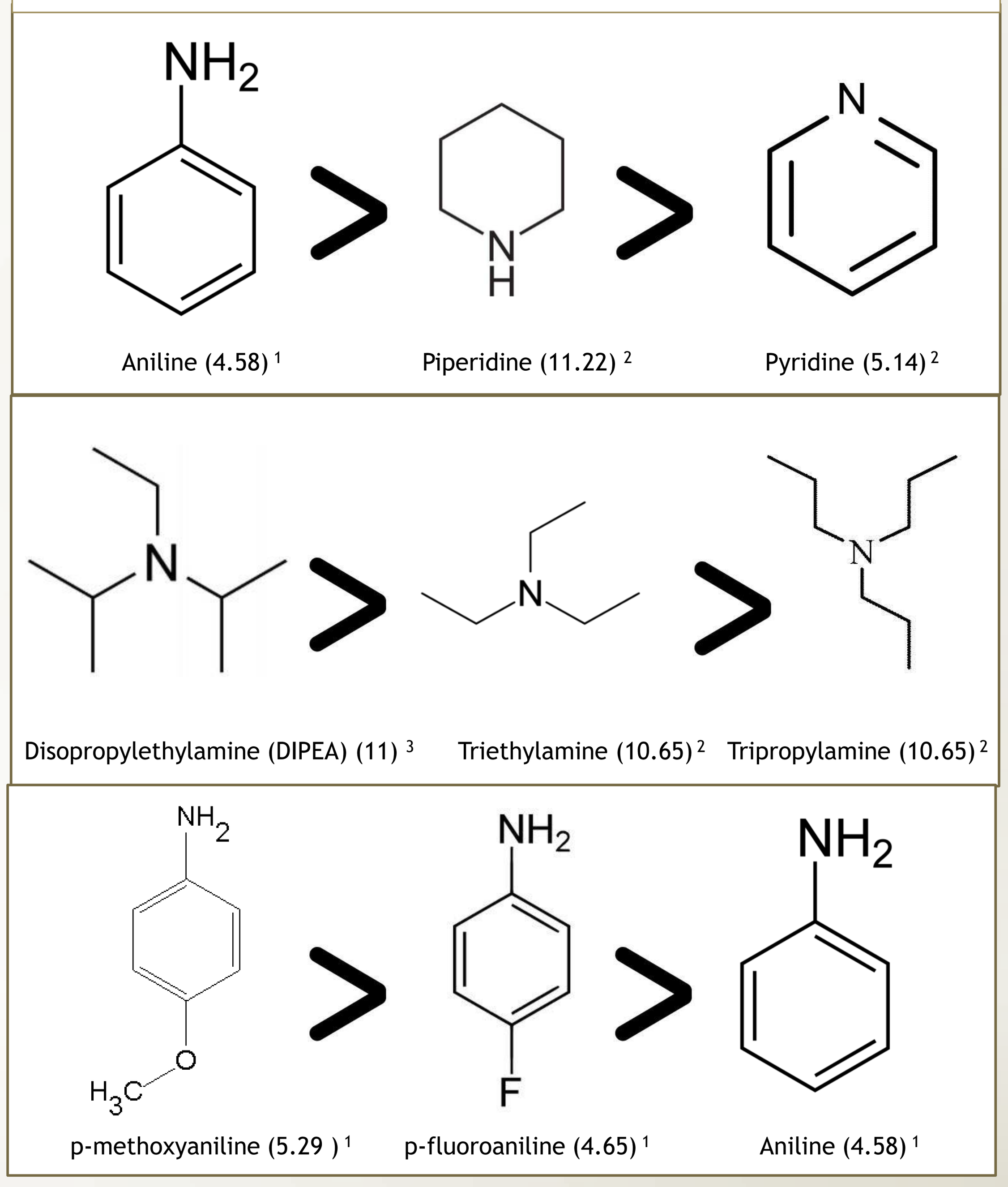
We are making a handheld nitrogen phosphorus detector (NPD) that the military and homeland security can use to detect toxic chemicals with high sensitivity and selectivity. The limit of detection (LOD) of aniline was determined for the NPD. In order to determine selectivity, anilines with differing functional groups were tested to determine the effect of electron donating and withdrawing groups. Addition of any functional groups were shown to increase sensitivity. Sensitivity of NPD is comparable with the common Flame Ionization Detector. Further optimization is needed to decrease background signal, which will allow for increased sensitivity.

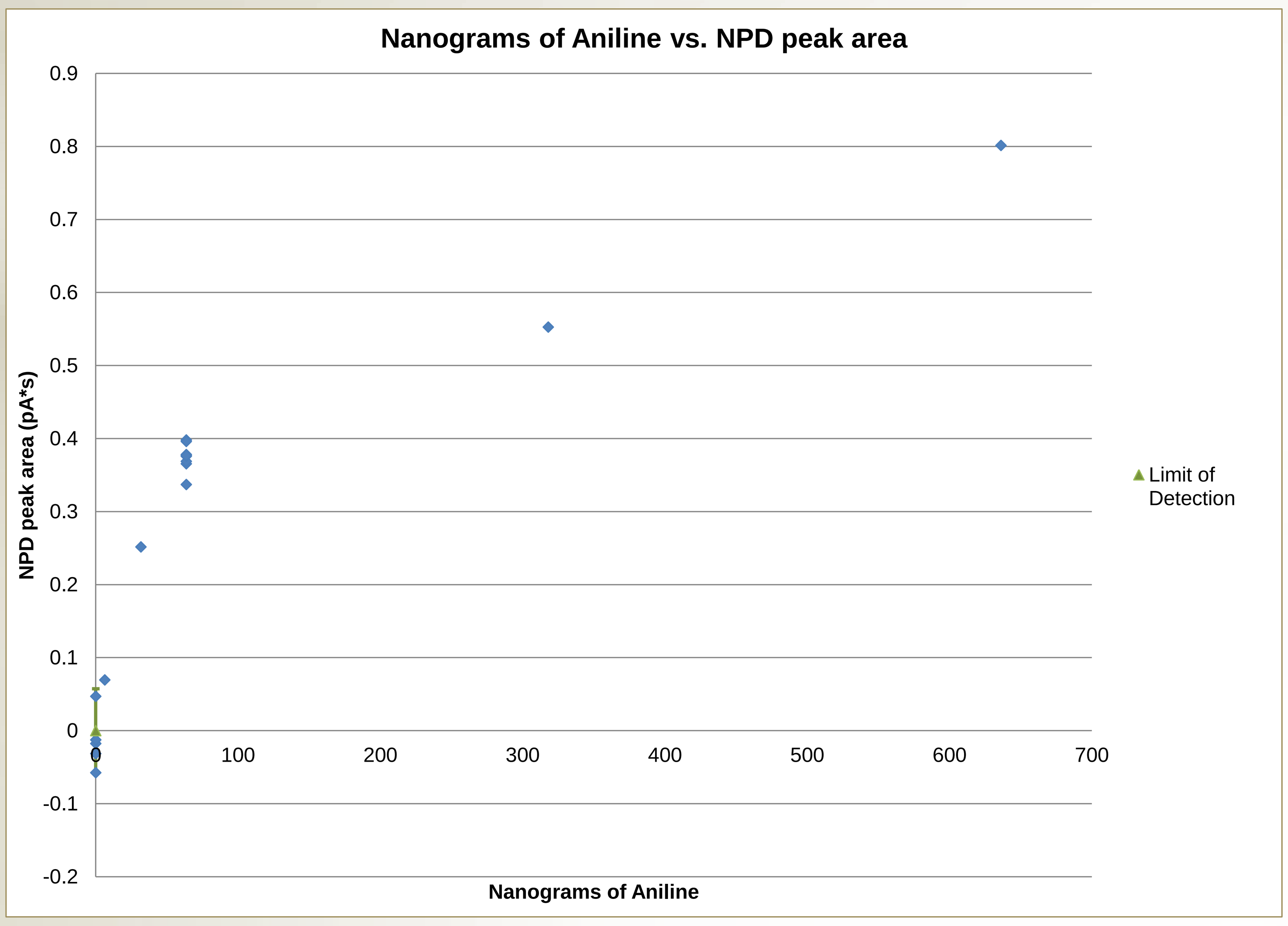
Introduction

Our goal is to make a small, portable, cheap, easy to use NPD that has high sensitivity and selectivity for toxic nitrogen and phosphorus containing compounds. In order to do this, the mechanism of detection needs to be fully understood. There is currently a benchtop NPD which is available, but the size is much too large to be practical for field use, and the mechanism of detection is still not understood. Our goal is to understand and further test the microfabricated NPD which we have created at Sandia.

Selectivity

Determined by peak area for each analyte, tested on a CsOH device. pKa values are in parentheses.





Results

Previous experiments have proven detection sensitivity is correlated with chemical structure. We chose some candidate analytes with varying electron donation properties, in order to test the hypothesis that NPD sensitivity correlates with Lewis basicity. Amines with similar structures were tested: pyridine, piperidine, aniline, DIPEA, triethylamine, and tripropylamine. Results of selectivity between analogous amines are shown above.

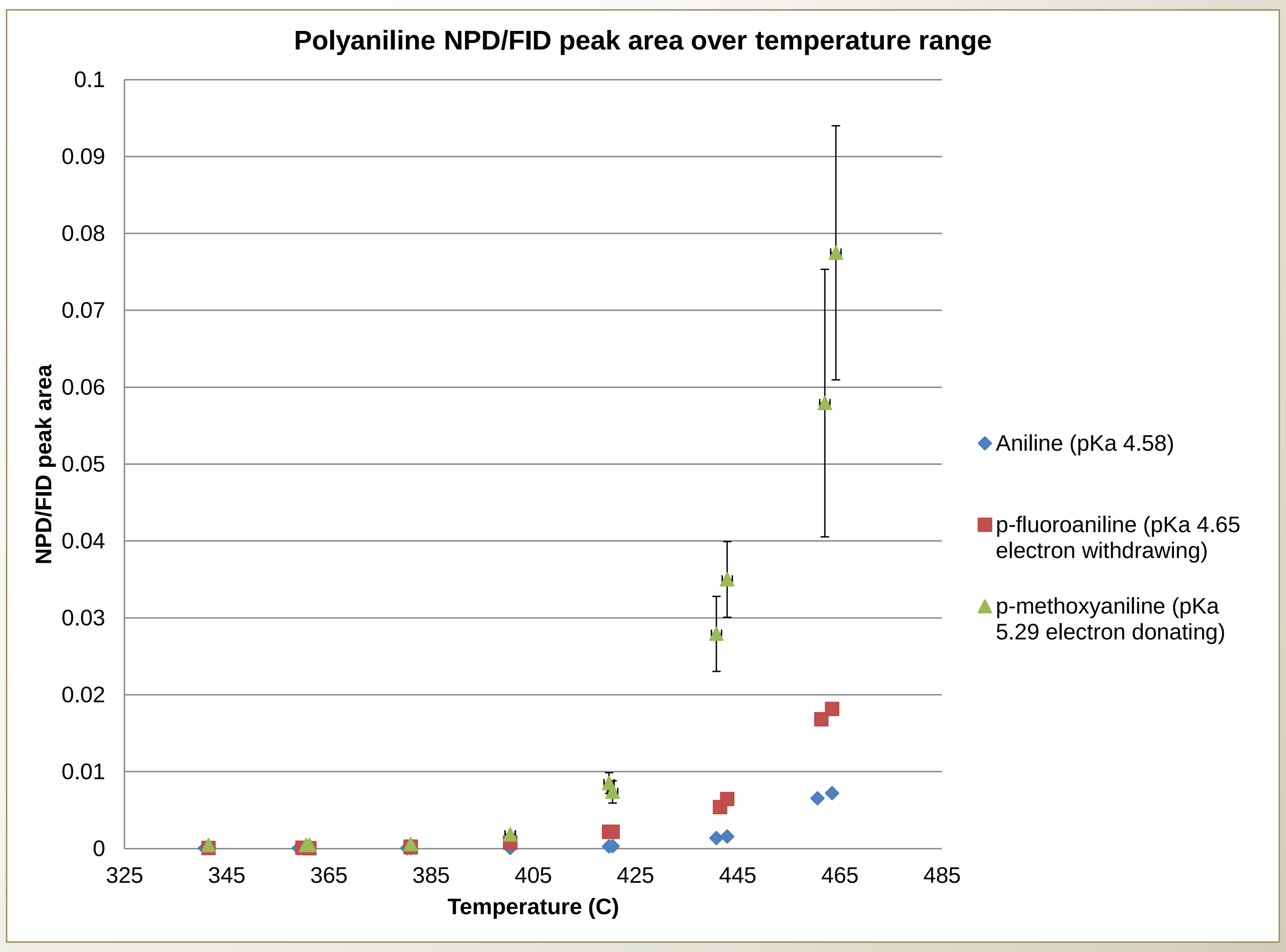
Aniline has a limit of detection (LOD) of 6.36ng on an NPD, which is comparable to a LOD of 2.15ng for a Flame Ionization Detector. Nanograms of aniline vs. NPD peak area is shown to the left.

Peak area of aniline, p-fluoroaniline and p-methoxyaniline at various operational temperatures are compared in the graph shown below.

Discussion

Testing the selectivity of the NPD determined that certain amines are detected better than others. Substituted anilines were found to be detected in a manner which was correlated with increased pKa values. Our future plans are to test each amine with a Kelvin Probe to determine the change in work function of a heated NPD when exposed to different analytes. This will determine if work function plays a key role in detection.

Calculation of the LOD allowed sensitivity of the NPD to be determined. These tests concluded that increased stability is required to allow for a higher operating temperature. Better electrical shielding is needed to minimize noise in baseline due to external sources. Device longevity needs to be greatly increased which can be done by optimizing pre/post coating treatment, and coating procedure.



References

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2. Williams, R., W. P. Jencks, and F. H. Westheimer. "pKa data compiled by R. Williams."
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