

Development of Prototype Boron-Doped Diamond Electrodes for Amperometric Detection in Ion Chromatography and High Performance Liquid Chromatography

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ABSTRACT

In comparison with other carbon electrodes, boron-doped diamond (BDD) electrodes offer advantages, such as a wider range of available detection potentials, improved stability of detection response, and higher sensitivity. The detection of new classes of analytes, such as carboxylic chelating agents, has also been reported using BDD electrodes.

We have carried out an in-depth study of detection performance of prototype BDD electrodes for S-containing compounds, carboxylic chelating agents, fat-soluble vitamins, peptides, proteins, phenols, nitroaromatics, catecholamines, and carbohydrates. The detection of some of these analytes, even with BDD electrodes, has not been reported before.

We will describe the optimization of detection potentials and report analytical performance data for each of the analytes.

EXPERIMENTAL

Liquid Chromatography

Dionex ICS-3000

- AS Autosampler
- DP dual pump
- ED detector equipped with a boron-doped diamond electrode (11.3 mm²)

Software

Dionex Chromeleon® Chromatography Data System

Chromatographic Conditions

See figures for details.

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APPLICATIONS

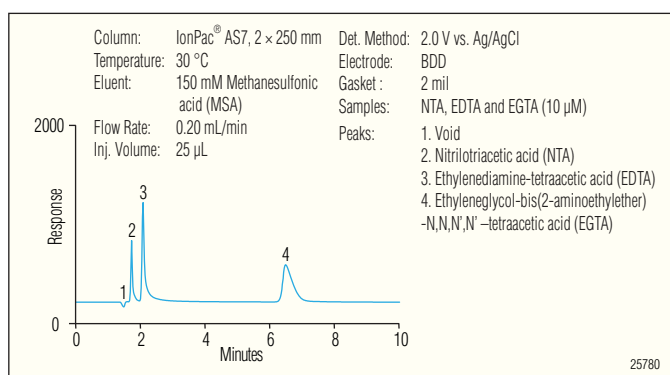


Figure 1. Carboxylic chelating agents.

Table 1. Calibration Results: Carboxylic Chelating Agents

	Limit of Detection (LOD) (µM)	Linear Range (µM)	Correlation Coefficient
NTA	0.026	0.10–1000	0.9977
EDTA	0.014	0.10–1000	0.9951
EGTA	0.025	0.10–1000	0.9996

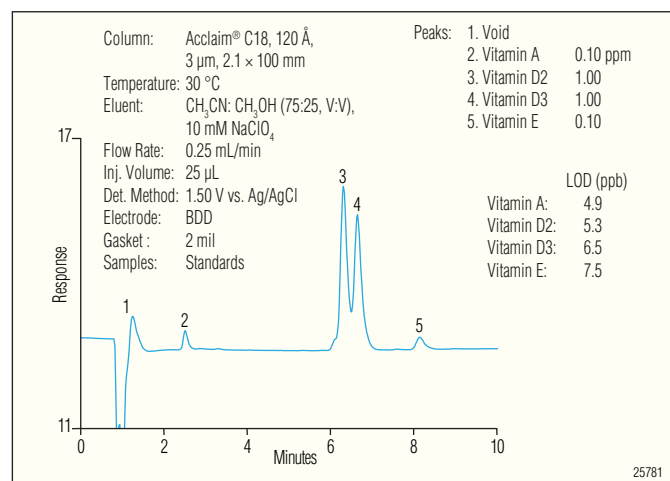


Figure 2. Fat-soluble vitamins.

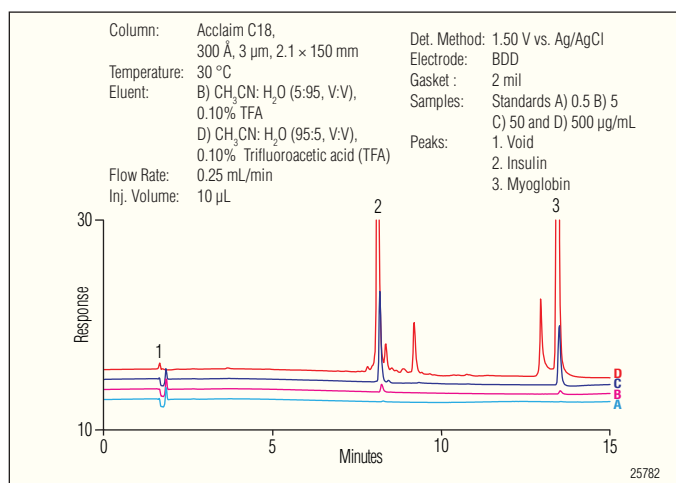


Figure 3. Peptides and proteins.

Table 2. Calibration Results: Peptides and Proteins			
	Limit of Detection (LOD) (µg/mL)	Linear Range (µg/mL)	Correlation Coefficient
Insulin	0.11	0.50–500	0.9926
Myoglobin	0.25	0.50–500	0.9996

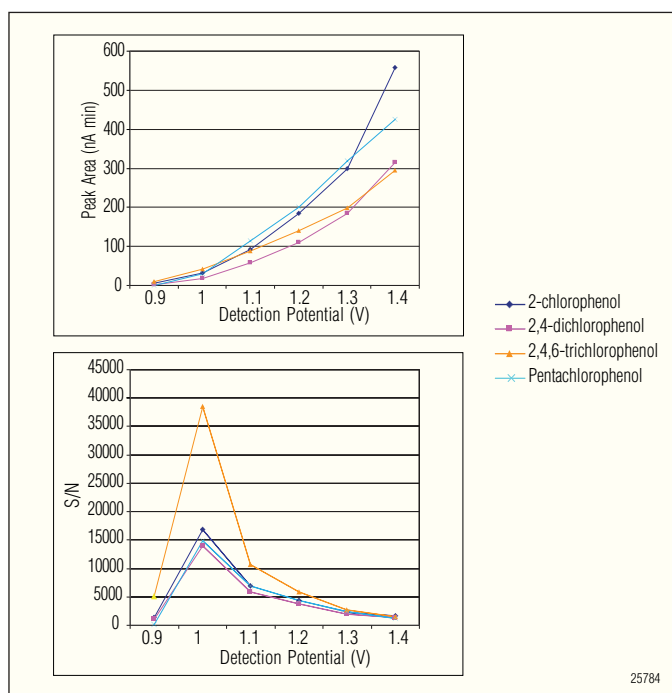


Figure 5. Hydrodynamic plots: chlorophenols peak height and signal-to-noise ratio vs. detection potential.

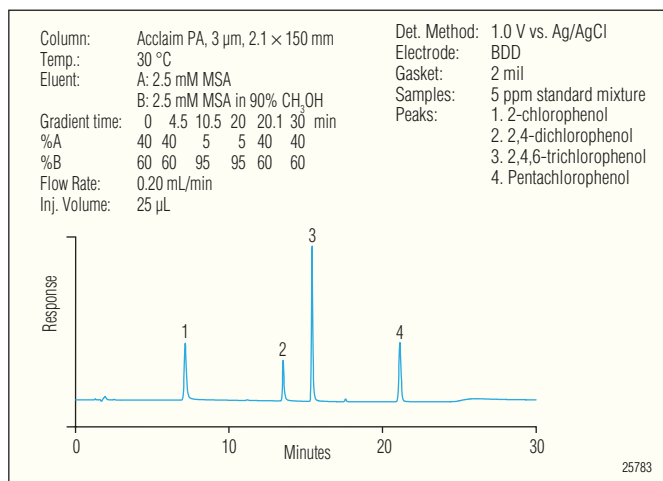


Figure 4. Chlorophenols: EPA priority pollutants.

Table 3. Calibration Results: Chlorophenols			
	LOD (ng/mL)	Linear Range (ng/mL)	Correlation Coefficient
2-chlorophenol	7	50 – 5000	1.0000
2,4-dichlorophenol	10	50 – 5000	0.9990
2,4,6-trichlorophenol	1	50 – 5000	0.9990
Pentachlorophenol	4	50 – 5000	0.9970

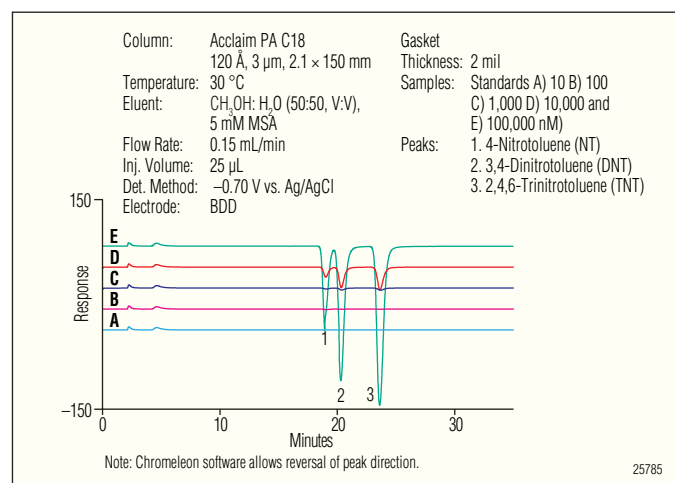


Figure 6. Reductive detection of nitrotoluenes.

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Table 4. Calibration Results: Nitrotoluenes				
	Limit of Detection (LOD) (nM / ppb)	Linear Range (nM)	Correlation Coefficient	RSD (%) 15 hr
NT	9.30 / 1.28	10–100,000	0.9996	1.64
DNT	8.06 / 1.47	10–100,000	0.9981	1.20
TNT	6.68 / 1.52	10–100,000	0.9991	1.20

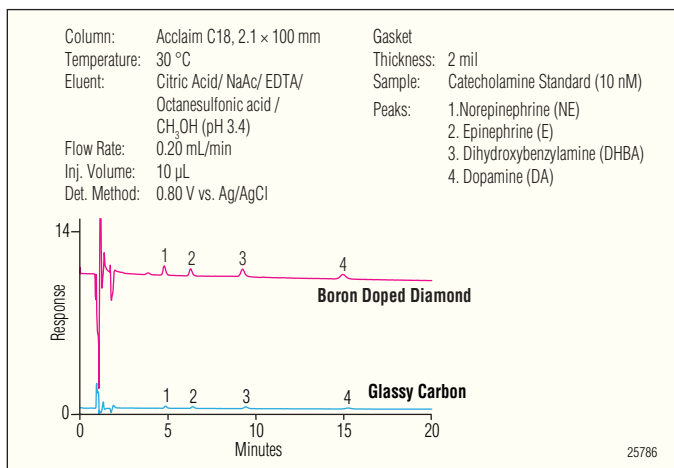


Figure 7. Catecholamines: BDD and glassy carbon (GC) electrodes.

Table 5. Comparison of Limit of Detection with BDD and Glassy Carbon Electrodes		
	BDD	Glassy Carbon
NE (nM)	0.56	0.65
E (nM)	0.73	0.79
DHBA (nM)	0.70	0.80
DA (nM)	1.19	1.96

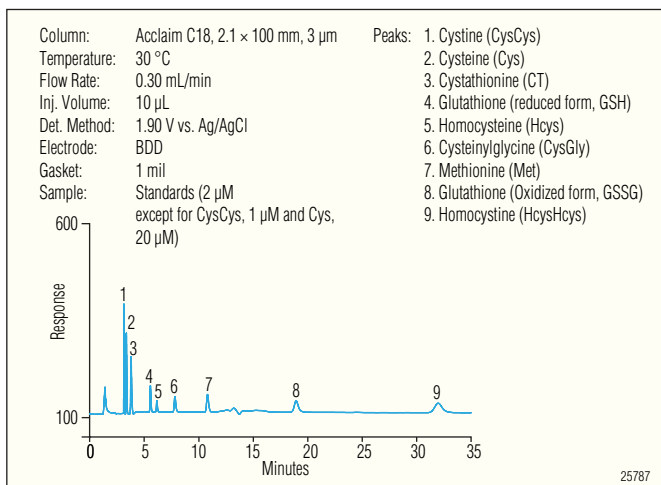


Figure 8. Thiols, disulfides, and thioethers.

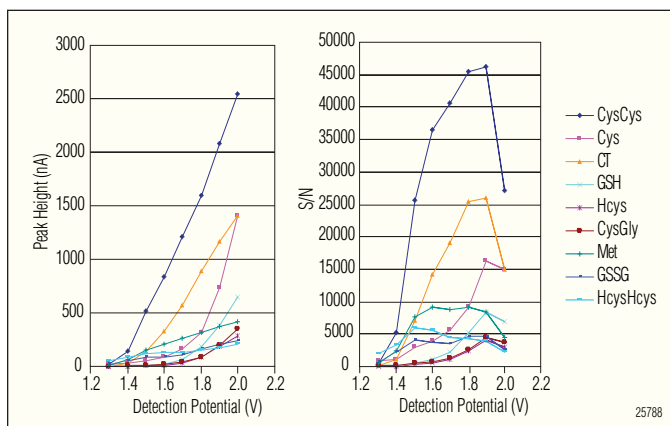


Figure 9. Hydrodynamic plots: thiols, disulfides, and thioethers peak height and signal-to-noise ratio vs. detection potential.

Table 6. Calibration Results: S-Containing Species			
	Limit of Detection (LOD) (nM)	Linear range (nM)	Correlation Coefficient
CysCys	0.28	1–10,000	0.9993
Cys	6.07	20–20,000	0.9973
CT	1.64	5–20,000	0.9998
GSH	3.58	20–20,000	0.9983
Hcys	8.57	20–20,000	0.9989
CysGly	5.00	20–20,000	0.9951
Met	5.29	20–200,000	0.9994
GSSG	9.15	20–20,000	0.9999
HcysHcys	13.5	20–20,000	0.9998

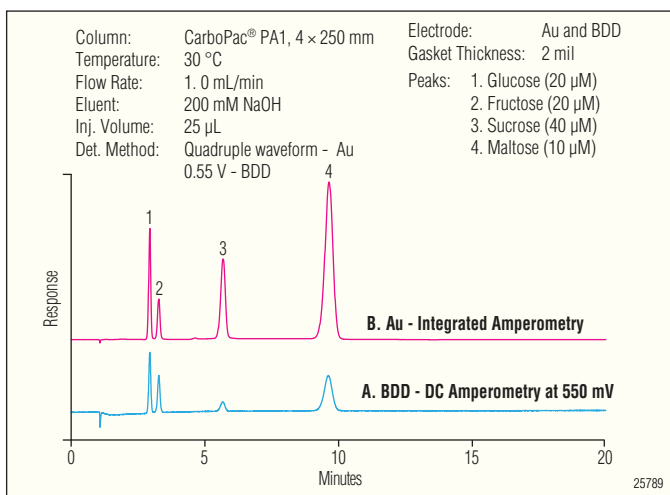


Figure 10. Mono- and disaccharides detected with BDD and Au electrodes.

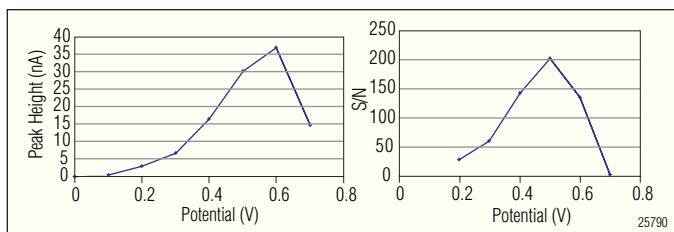


Figure 11. Hydrodynamic plots: fructose peak height and signal-to-noise ratio vs. detection potential.

CONCLUSIONS

- Developed new prototype BDD electrodes:
 - Wide detection potential window
 - Oxidative and reductive detection
- Optimized detection potentials for a variety of compounds (see Figures 5, 9, and 11)
- Achieved a broader range of linearity for thiols, thioethers, and disulfides
- Developed new applications (reductive detection of nitrotoluenes, oxidative detection of chelates, peptides, proteins, and fat-soluble vitamins)

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