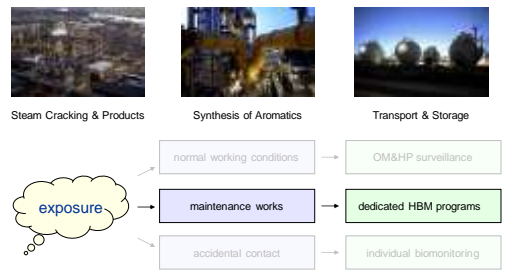


Biomonitoring during large-scale maintenance works in the chemical industry - the benzene experience

Bader M, Will W, Yong M, Neumann S, Pluto RP, Oberlinner Ch, Nasterlack M

BASF SE
Occupational Medicine & Health Protection
Chief Medical Officer: Dr. med. Stefan Lang
67056 Ludwigshafen, Germany

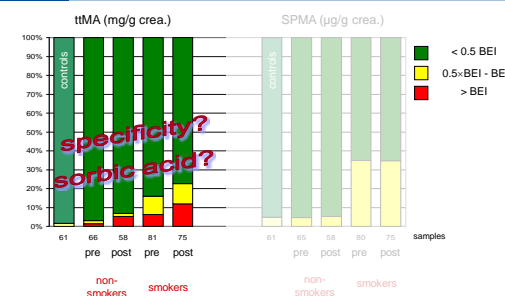
BASF Biomonitoring of benzene exposure



BASF Urinary Biomarkers of Benzene

	<chem>HOOC-CH=CH-COOH</chem> trans,trans-muconic acid ttMA	<chem>HOOC-CH2-CH2-COOH</chem> S-phenylmercapturic acid SPMA	<chem>c1ccccc1</chem> benzene
analytical method	HPLC-UV LOD 0.02 mg/L	GC-MS LOD 1 µg/L	Headspace-GC-MS LOD 0.02 µg/L
Assessment Value EKA Germany (DFG)	2 mg/L	45 µg/g crea.	---
Assessment Value BEI USA (ACGIH)	0.5 mg/g crea.	25 µg/g crea.	---
background values	< 0.2 mg/g crea.	< 0.2 µg/g crea. (NS) < 5.0 µg/g crea. (S)	< 1 µg/L

BASF Biomonitoring under normal working conditions Synthesis of Aromatics 2009



BASF Aims of the study

- to summarise benzene exposure data during **typical maintenance works**
- to identify work tasks with **higher exposure**
- to compare the urinary biomarkers for benzene (**ttMA, SPMA, benzene**)
- to derive a possible **assessment value** for urinary benzene

re-analysis of data from two plants and two maintenance jobs (2 - 4 weeks)

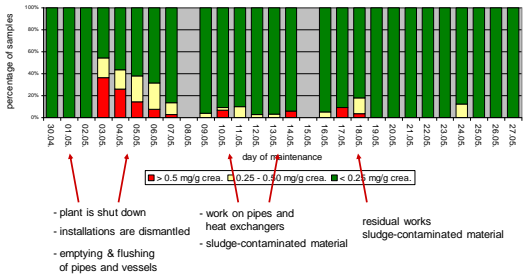
Steamcracker Plant 2008 & 2011
Aromatics Plant 2006 & 2011

post-shift urine samples (pre/post for Aromatics Plant 2011)
analysis of urinary ttMA in 2006/2008
analysis of urinary ttMA, SPMA and benzene in 2011

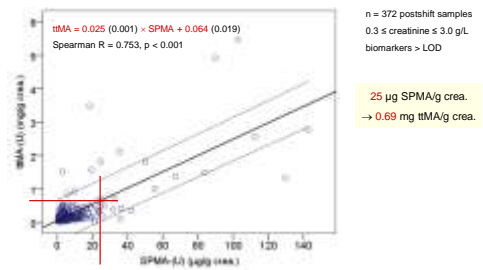
BASF Results of the biomonitoring analyses

	Aromatics Plant maintenance 2006 (n = 183)	Steamcracker maintenance 2008 (n = 148)	Aromatics Plant maintenance 2011 (n = 182)	Steamcracker maintenance 2011 (n = 490)
ttMA (mg/g crea.)				
median	0.08	0.21	0.12	0.10
95% range	0.46	2.21	0.44	0.50
range	0.01 - 4.14	0.01 - 4.86	0.01 - 0.69	0.01 - 5.46
SPMA (mg/g crea.)				
median	---	---	1.7	1.7
95% range			21.5	15.9
range			0.5 - 32.7	0.2 - 142.5
benzene (µg/L)				
median	---	---	0.6	0.6
95% range			13.1	6.5
range			0.01 - 24.2	0.01 - 135.4

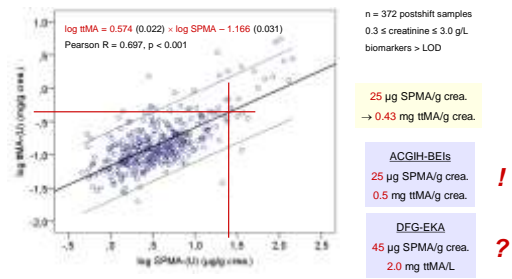
BASF The Chemical Company
 Steamcracker maintenance 2011
 trans,trans-muconic acid in urine



BASF The Chemical Company
 Relation between urinary ttMA and SPMA (I)



BASF The Chemical Company
 Relation between urinary ttMA and SPMA (II)



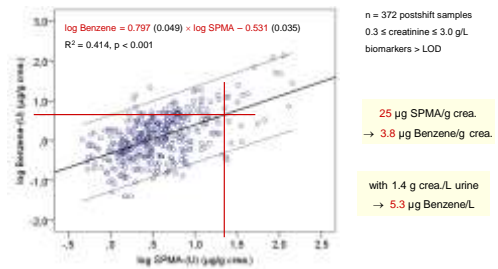
BASF The Chemical Company
 Urinary benzene vs. ttMA and SPMA

log-transformed data
 Pearson correlation coefficients
 all correlations p < 0.001

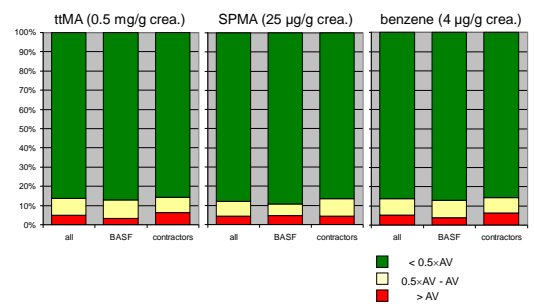
n = 372 postshift samples
 0.3 ≤ creatinine ≤ 3.0 g/L
 biomarkers > LOD

log-transformed	ttMA (mg/L)	ttMA (mg/g crea.)	SPMA (µg/L)	SPMA (µg/g crea.)
urinary benzene (µg/L)	0.562	0.462	0.673	0.553
urinary benzene (µg/g crea.)	0.434	0.503	0.615	0.644

BASF The Chemical Company
 Relation between urinary benzene and SPMA



BASF The Chemical Company
 Steamcracker 2011
 Exposure categories and biomarkers



- maintenance works are a **relevant source** of exposure to benzene
- exposure is more **frequent during emptying & flushing** of pipes and vessels
- the results for urinary tTMA and SPMA confirm the **ACGIH-BE1 relation**
- urinary benzene shows a **similar diagnostic validity** as tTMA and SPMA
- the diagnostic validity of tTMA needs to be **discussed** (specificity)
- **25 µg SPMA/g crea. (BE1)** correspond to **~ 4 µg benzene/g crea.** (~ 5 µg/L)

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	Hoet et al. 2009 (ADEC 82:985-995)	Fustinoni et al. 2011 (Biomarkers 16:334-345)	Hopf et al. 2011 (ADEC, online first)	this study (aromatics plant 2011)
study group	110 petrochemical workers	71 refinery workers 97 internal controls 108 external controls	25 off-shore petroleum production workers 18 controls	97 pre-shift samples 85 post-shift samples 19 maintenance workers
exposure	89 % < 0.01 ppm 98 % < 0.05 ppm	(A) 0.06 ppm (median) (B) --- (C) < 0.001 ppm (median)	90 % > 0.001 ppm AM 0.13 ppm	--- (<< 1 ppm)
urinary benzene	non-smokers (n = 86) 0.22 µg/L (< 0.1 – 5.4) 0.16 µg/g (< 0.1 – 2.1) smokers (n = 24) 0.41 µg/L (0.11 – 5.51) 0.24 µg/g (0.01 – 2.41)	(A) 0.550 µg/L (0.117 – 7.487) (B) 0.320 µg/L (0.083 – 2.316) (C) 0.155 µg/L (0.054 – 2.554)	pre-shift workers 0.8 µg/L controls 0.1 µg/L post-shift workers 2.1 µg/L controls 0.4 µg/L	pre-shift 1.44 µg/L (AM) 0.50 µg/L (med) post-shift 2.42 µg/L (AM) 0.57 µg/L (med)

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