

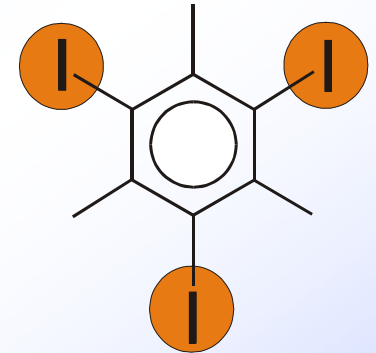
Treatment of urine with zero-valent iron to minimize the environmental contamination with iodinated X-ray contrast media

Anke Putschew, Ulf Miehe, Agueda Solis Téllez and
Martin Jekel

Introduction

Iodinated X-ray contrast media (ICM): derivatives of 2, 4, 6-tri-iod benzene

Application: for X-ray examinations of organs and vessels with a dose of up to 100 g ICM



Properties: ICM are designed to be **very stable** to avoid interactions after application and **very polar** to guaranty a rapid elimination via urine

Fate and behavior: with the urine the compounds are discharged into municipal waste water treatment plants (WWTP), which are not able to remove the compounds....

Introduction

...ICM are detectable in all parts of the water cycle, which are influenced by WWTP effluents

	AOI $\mu\text{g/L}$	Iopromide $\mu\text{g/L}^*$
Hospital waste water	366**	621**
WWTP influent	112**	n.d.
WWTP effluent	107**	n.d.
Surface water	9.6***	0.86***
Ground water	4.2***	0.045***

* Consumption in Germany ca. 130 t/a, ** mean value 24 h mixed samples over one week, *** annual average values, n.d. not determined

Introduction

Consumption: 3500 t/a world wide, 50 % in hospitals

AOI [$\mu\text{g/L}$] and AOI load [g/d] of a hospital (300 beds)

	flow rate (m^3)	AOI [$\mu\text{g/L}$] 24 h mixed samples	AOI load [g/d]
Tue	428.4	346.0	148.2
Wed	1143.5	34.2	39.1
Thu	425.7	377.4	160.7
Fri	348.7	629.7	219.6
Sat	446.3	1102.1	491.9
Sun	137.5	44.9	6.2
Mon	570.2	24.6	14.0
Sum			1079.7

a small hospital can discharge up to 1 kg AOI/week!

Introduction

Reduction of the emission into the aquatic environment:
separation of urine in hospitals, followed by a specific
treatment

Specific treatment: reaction with zero-valent iron

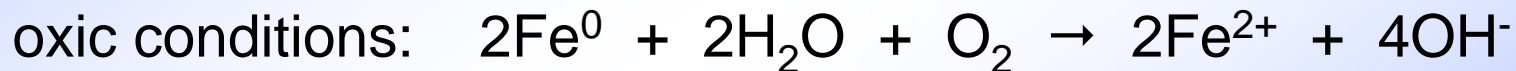
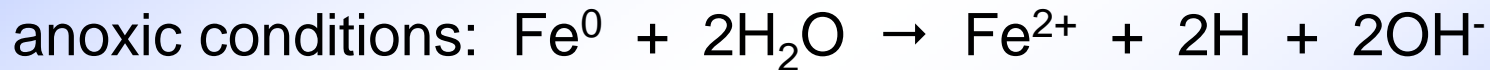
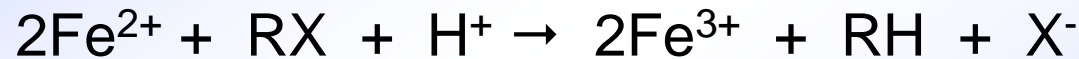
Dehalogenation by zero-valent iron

A dehalogenation in a $\text{Fe}^0/\text{H}_2\text{O}$ system is possible according to the following reactions:

(1) direct electron transfer



(2) reduction by Fe^{2+} :

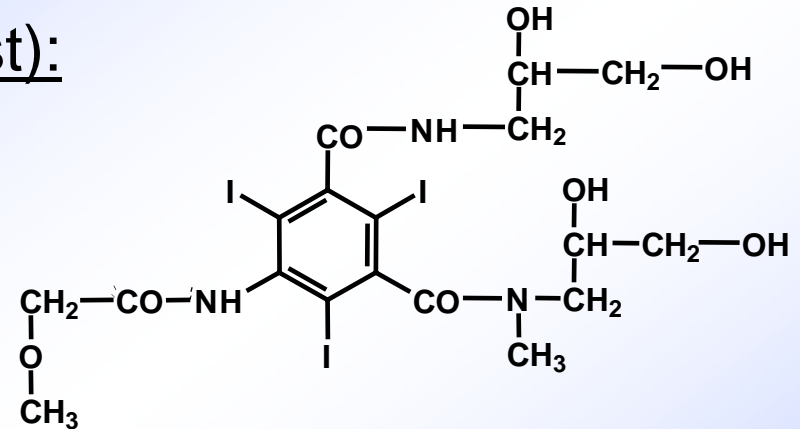


(3) hydrogenation:



Iopromide/Fe⁰ – anoxic condition

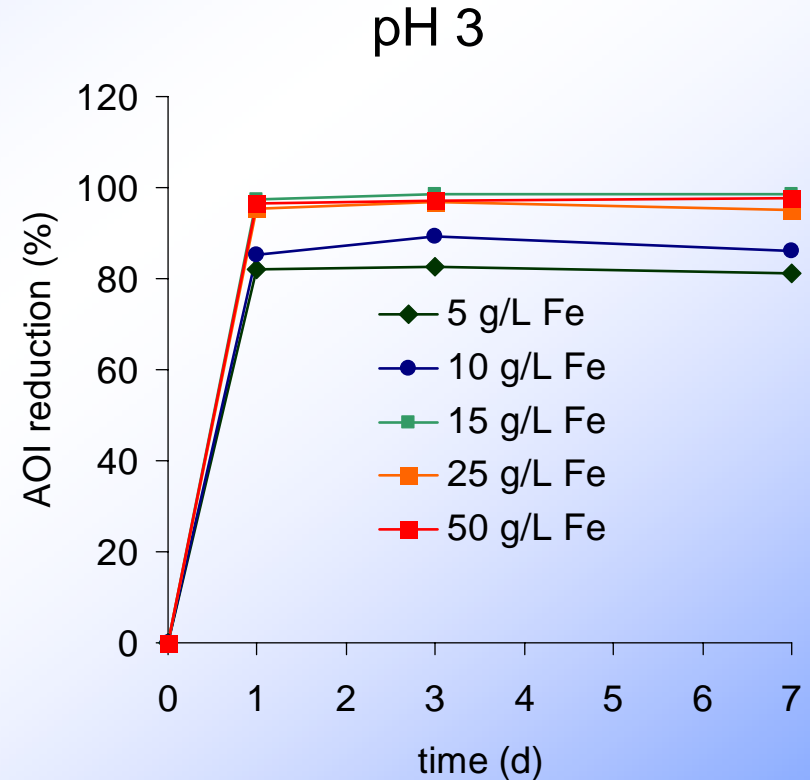
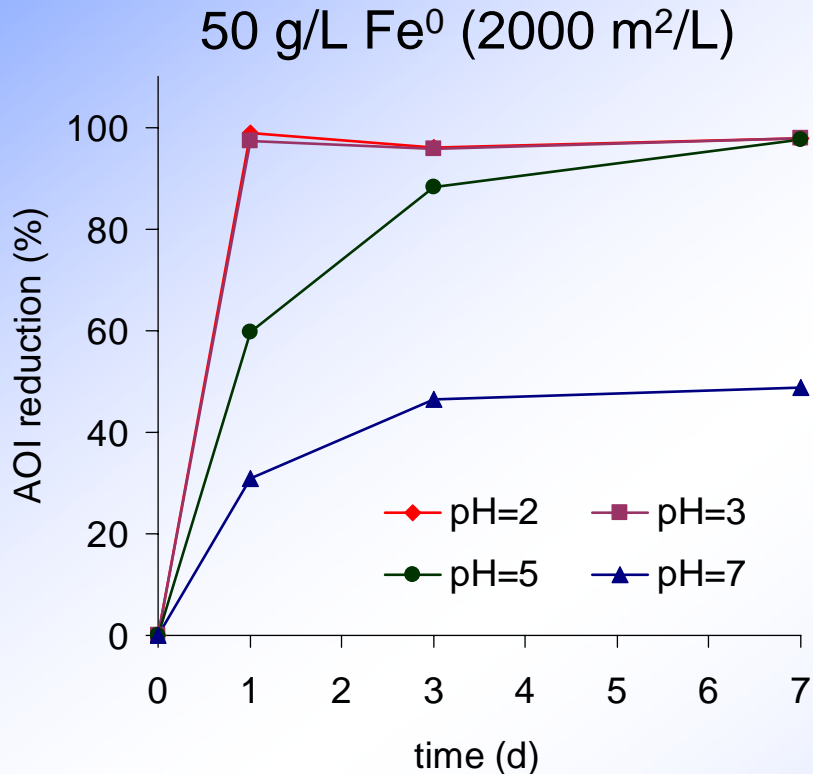
Experimental (shaking batch test):



- Iopromide (10 mg/L) in ultra pure water, oxygen was removed by nitrogen, zero-valent iron powder was added (BET 40.1 m²/g)
- initial pH and amount of iron added were varied
- AOI- and the iodide concentration was determined

Iopromide/Fe⁰ – anoxic condition

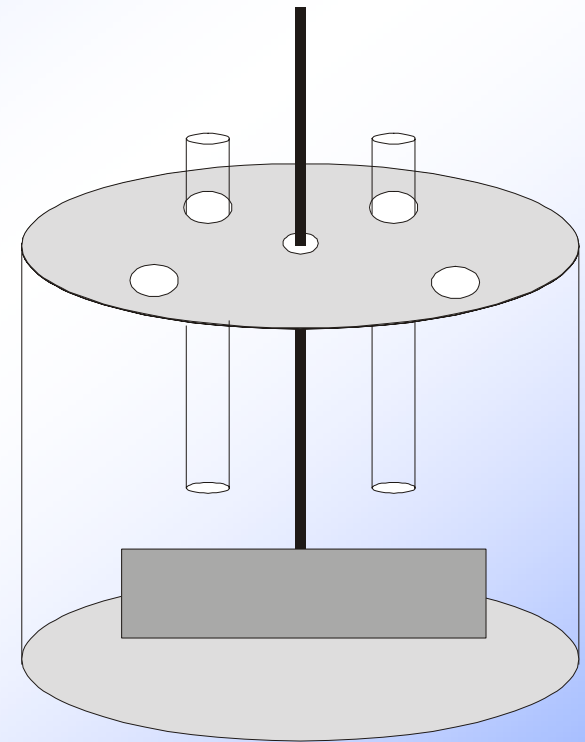
10 mg/L Iopromide (= 4.8 mg/L AOI)



Iopromide/Fe⁰

Experimental (batch test, stirred, dark):

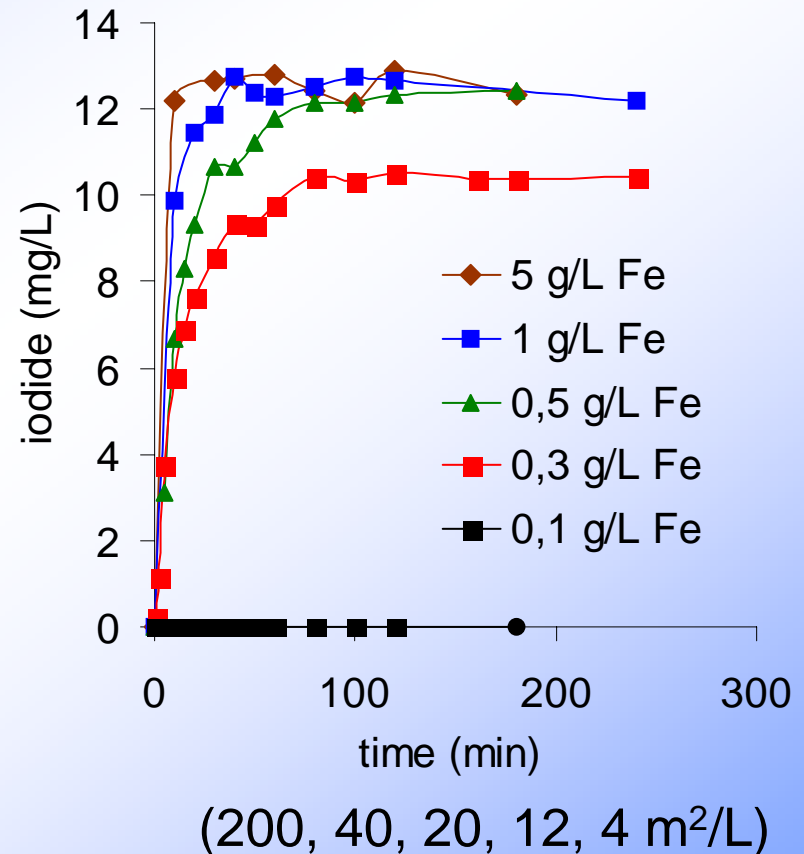
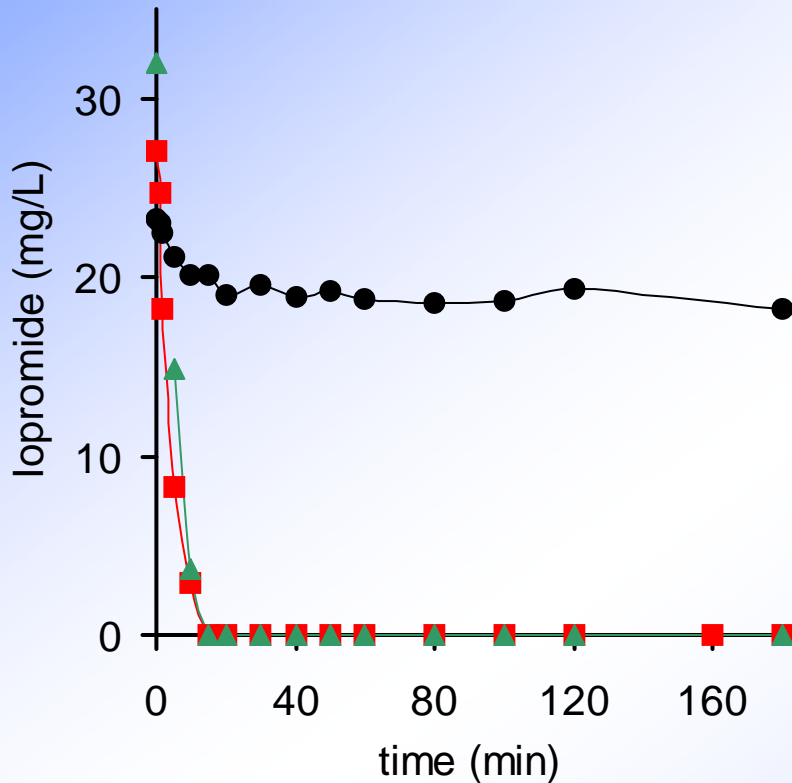
- Iopromide (30 mg/L) dissolved in ultra pure water, zero-valent iron powder was added (BET 40.1 m²/g)
- initial pH and amount of iron added were varied
- pH, O₂ and ESH were measured, Iopromide, iodide and AOI concentration was determined



V = 500 ml

Iopromide/Fe⁰

30 mg/L Iopromide (= 14.5 mg I⁻), pH 2



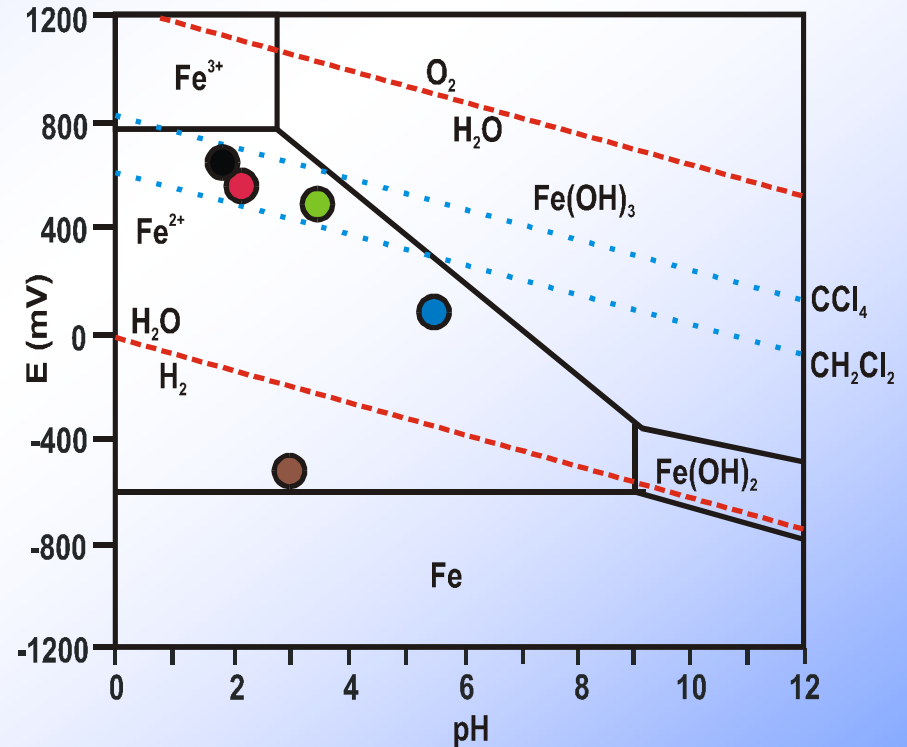
(200, 40, 20, 12, 4 m²/L)

Iopromide/Fe⁰

30 mg/L Iopromide, pH 2

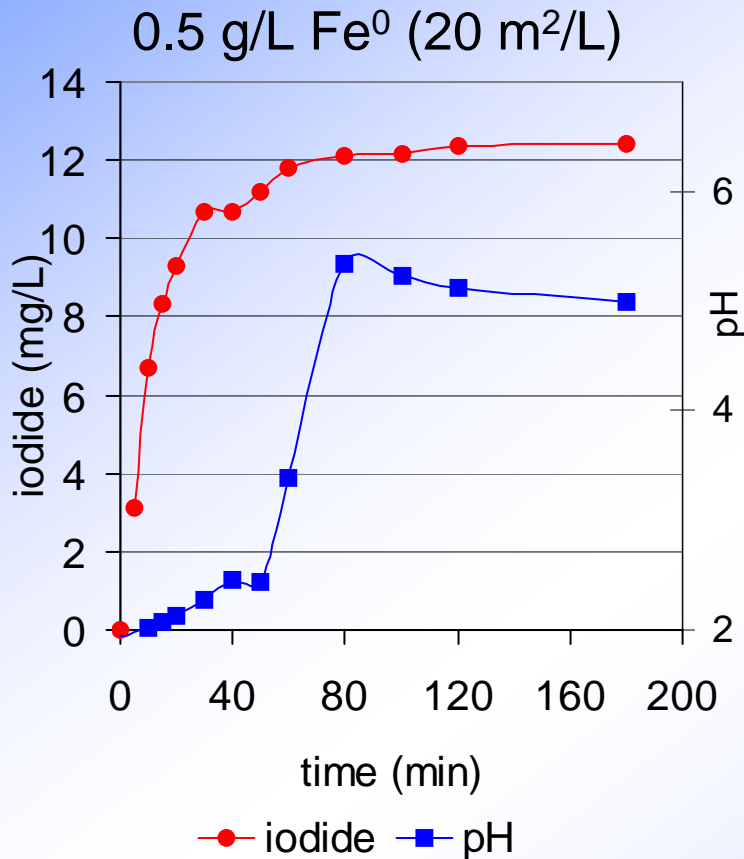
Fe g/L	time (min)	E (mV)	pH	iodide (%)*
5	30	-543	3	88
1	40	164	5.6	88
0.5	60	542	3.4	82
0.3	30	599	2.1	60
0.1	180	685	1.9	0

* related to the maximal iodide concentration which can be developed



Iopromide/Fe⁰

30 mg/L Iopromide (= 14.5 mg I⁻), pH 2



two reaction mechanisms are possible:

0-40 min:



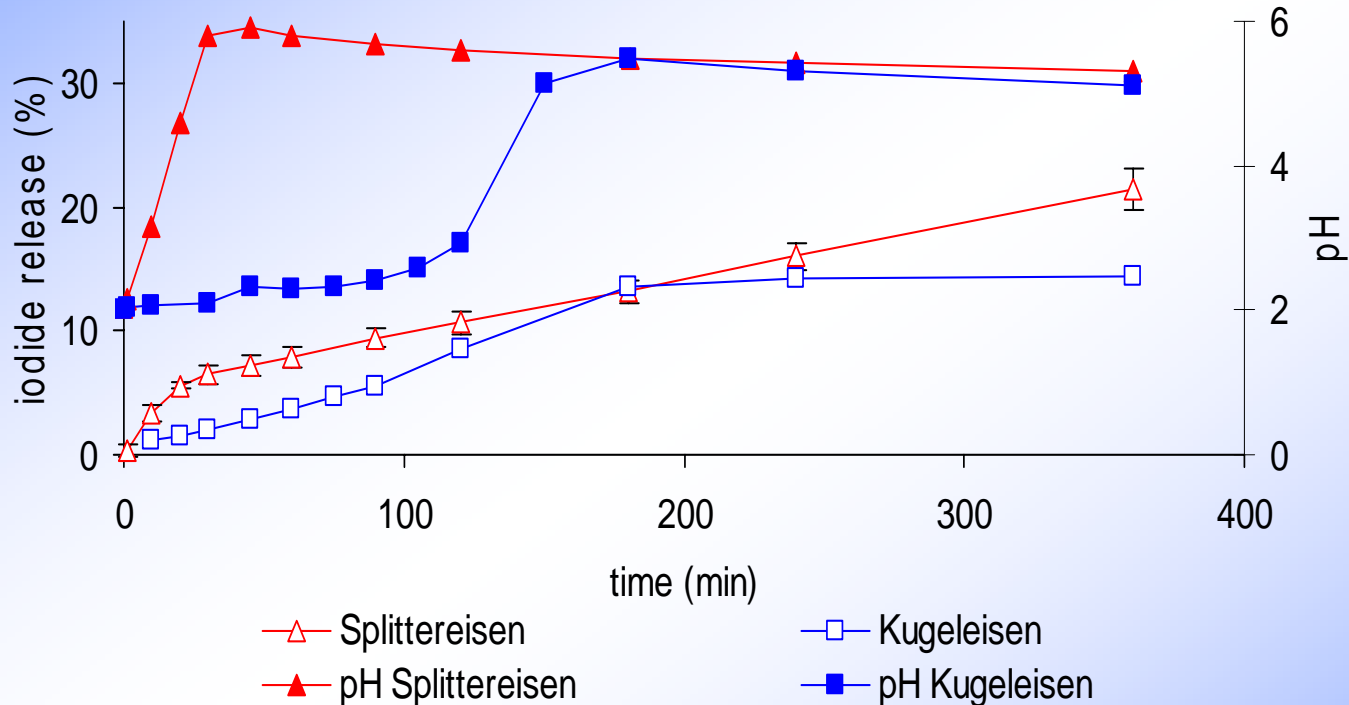
40-180 min:



- pH decrease is due to the hydrolysis of Fe²⁺ and Fe³⁺

Iopromide/Fe⁰

Iopromide $c_0 = 1.6$ g/L, 20.05 m²/L of different iron type

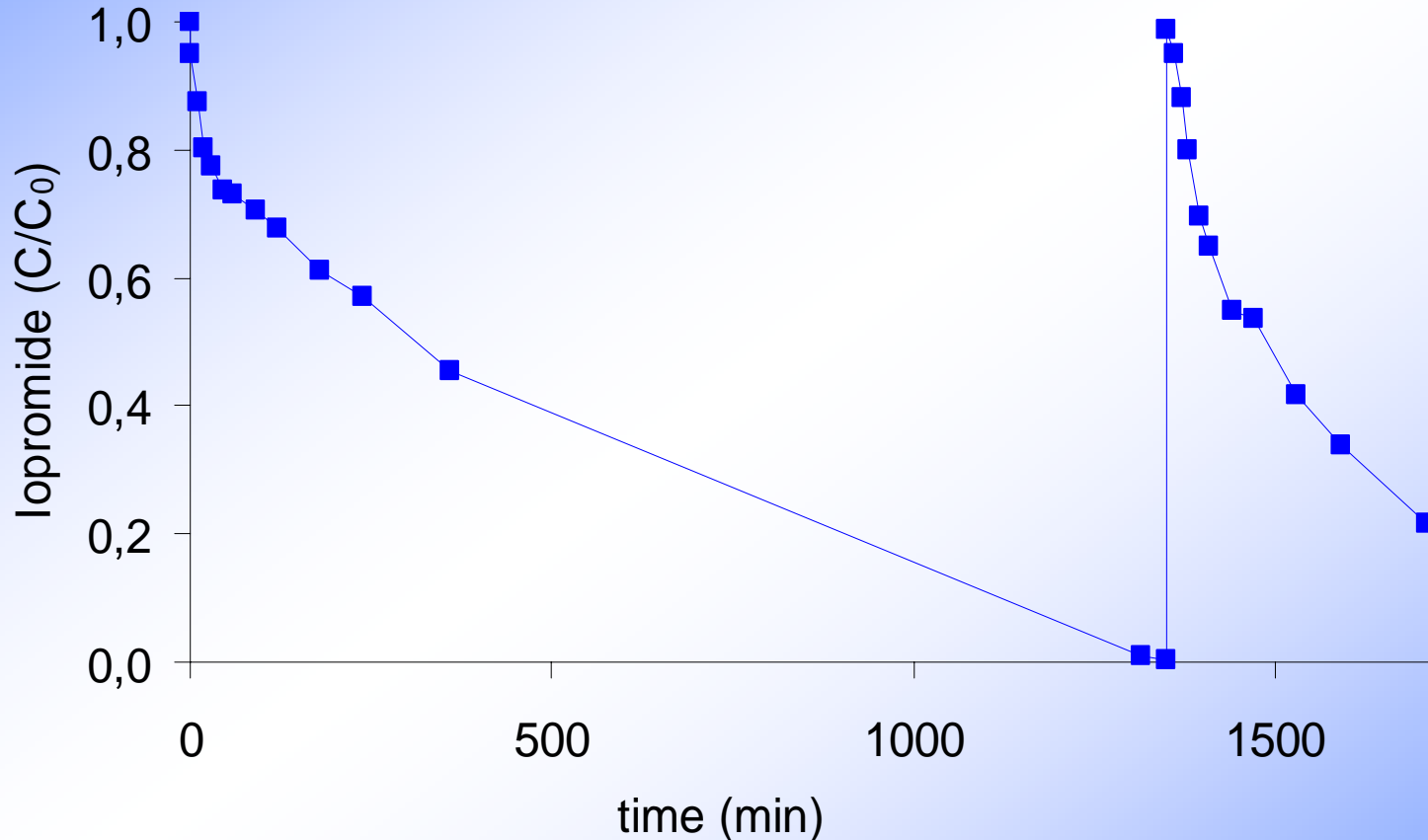


Splitterereisen: 0.3-3mm, surface area 0.5 m²/g

Kugeleisen = spherical iron diameter 1-1.6 mm, surface area 0.043 m²/g

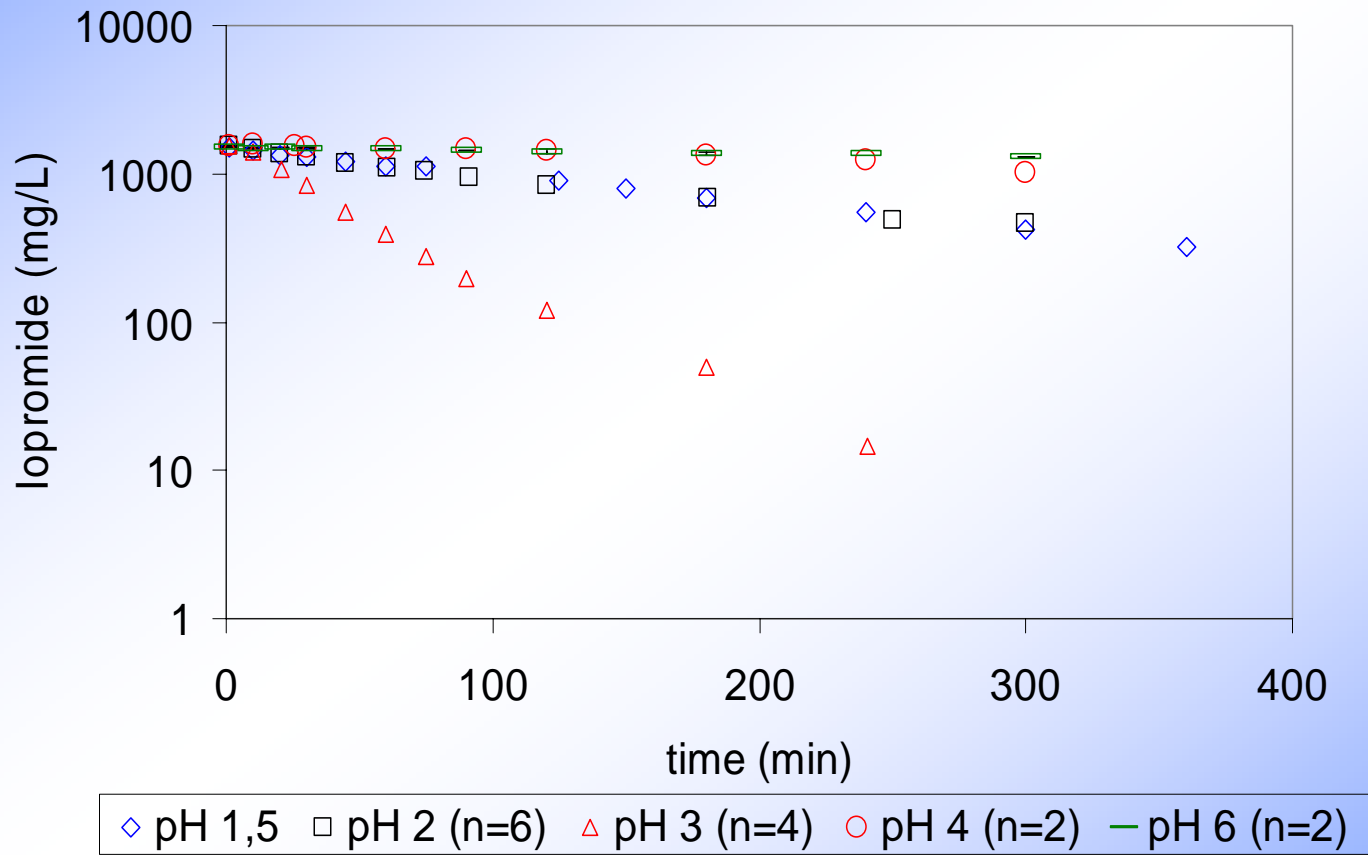
Iopromide/Fe⁰

Iopromide $c_0 = 1.6$ g/L, 40.1 g/L Fe⁰ (0.3-3 mm, 20.05 m²/L)



Iopromide/Fe⁰

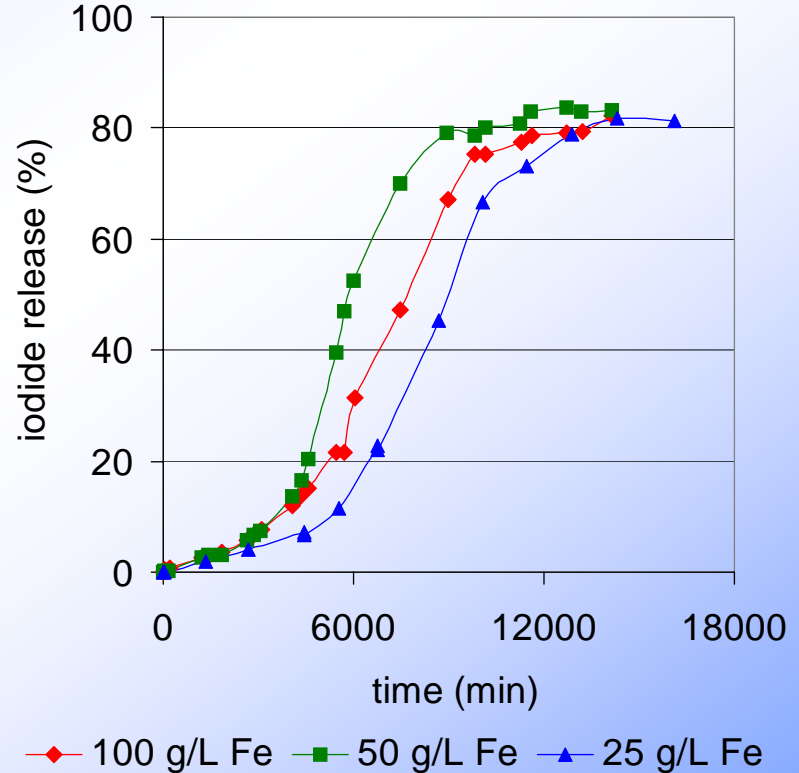
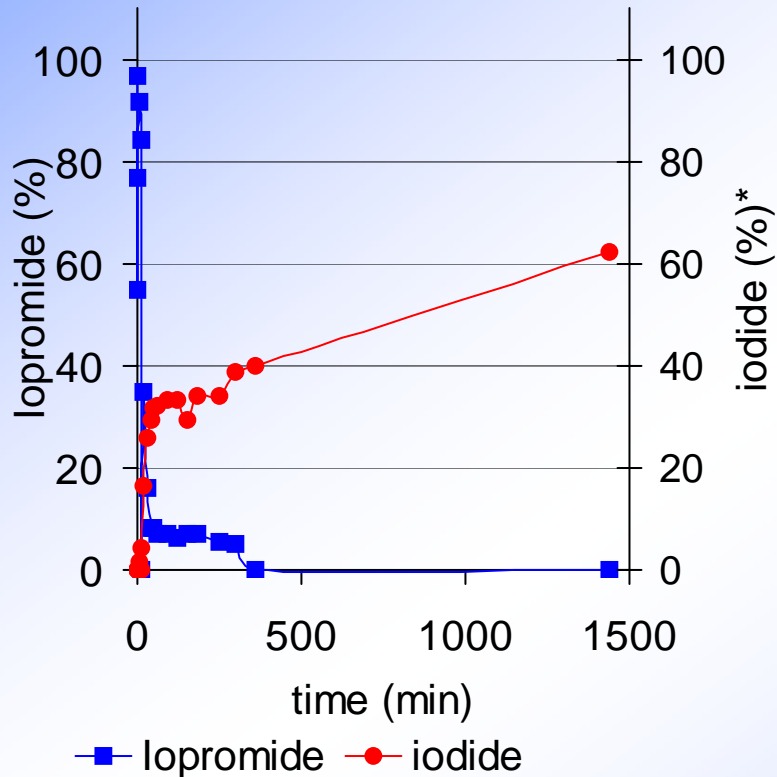
Iopromide $c_0 = 1.6$ g/L, 40.1 g/L Fe⁰ (0.3-3mm, 20.05 m²/L)



Iopromide/Fe⁰

1600 mg/L Iopromide
in urine, pH 2,
Fe⁰ (powder): 50 g/L = 2000 m²/L

urine collected in a hospital,
AOI 18 g/L, pH 2,
Fe⁰ (0.3-3mm)
surface area: 50-12.5 m²/L

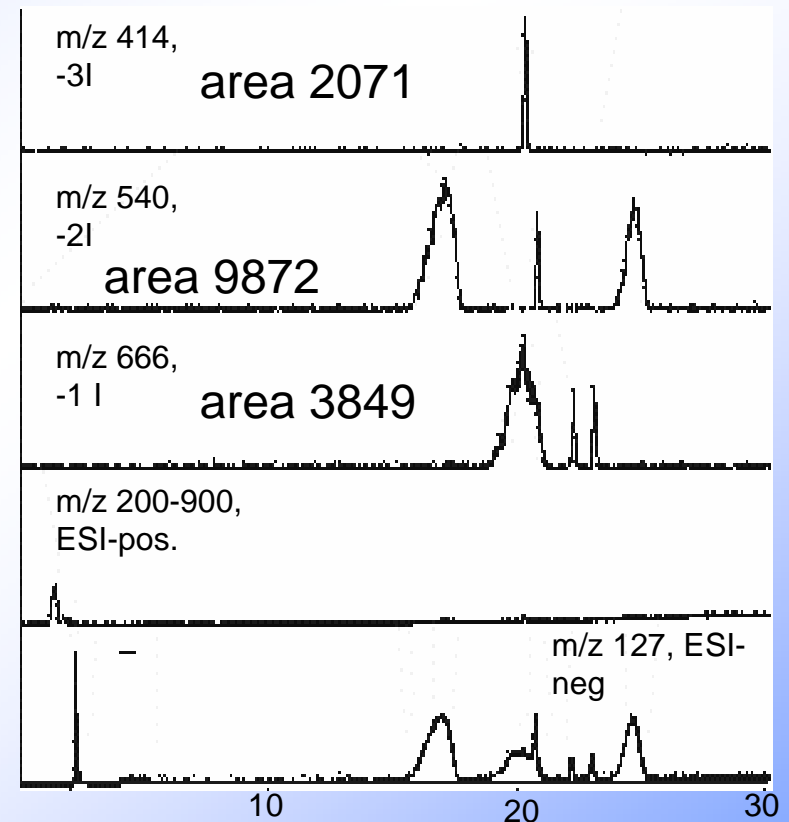
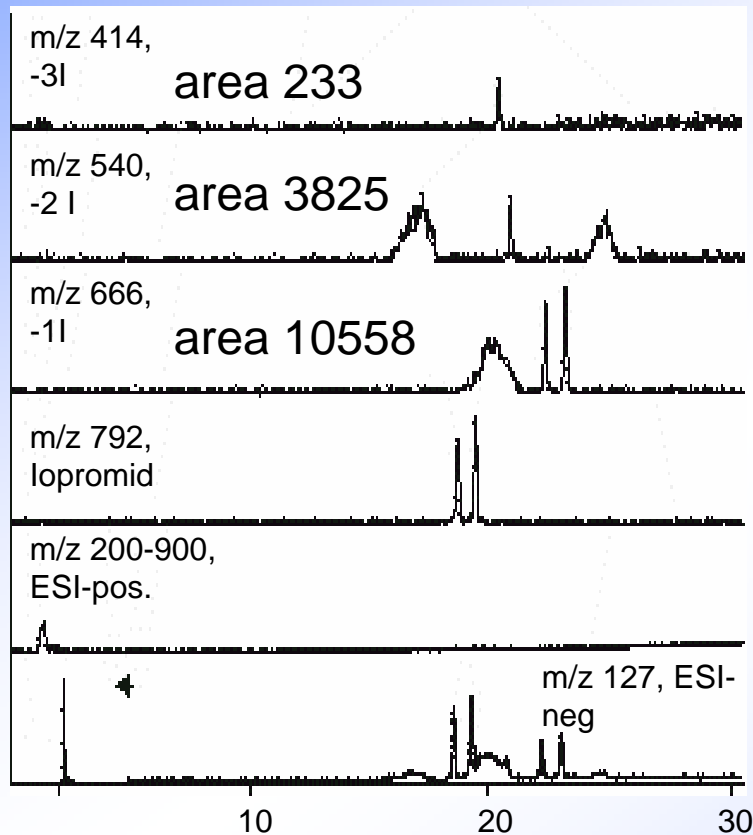


Iopromide/Fe⁰

Iopromide (1.6 g/L) in urine, 50 g/L Fe powder, pH 2

reaction time: 30 min

24 h



retention time (min)

Conclusions

- Iopromide, respectively iodinated X-ray contrast media (ICM) can be deiodinated by zero-valent iron
- the reaction yield/time depends on the added amount and type of iron, respectively the iron surface area. The amount of added iron influences, among others the pH and the redox potential
- the deiodination is possible at a redox potential lower 600 mV, and as lower the potential as faster the reaction
- there is more than one mechanism responsible for deiodination
- even in the complex matrix urine ICM can be deiodinated

Conclusions

- the three iodine atoms bound to Iopromide are substituted by hydrogen sequentially

Outlook

- the mechanism will be investigated more in detail
- the biodegradability of the deiodinated compounds will be investigated
- recycling of the iodine will be investigated

Acknowledgements

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THANK´S FOR LISTENING