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Experimental characterization and technical application of zeolites for selective separation of inhalative anaesthetic gases out of the expiration air of a patient during sedation

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Introduction

The use of low-solubility volatile inhalation anaesthetics can be of benefit to day-case anaesthesia as it allows more rapid emergence and recovery. However, most of the used gases are halogenated ethers. Only a fraction (0,02 - 5 %) of the applied amount is absorbed by the patient. The waste anesthetic gases are either released into the operating room or directly into the free atmosphere [1 - 2].

Previous studies have been actively performed on the application of activated carbons for adsorption of these group of gases [3 - 4]. Despite their high adsorption capacities, a long term technical application of these materials is very limited.

On the other hand, most of the studies performed on zeolites were based on evaluation of the adsorption capacity using static gravimetric method [5 - 6]. In addition some of the previously studied anaesthetic gases are not any more in practical use.

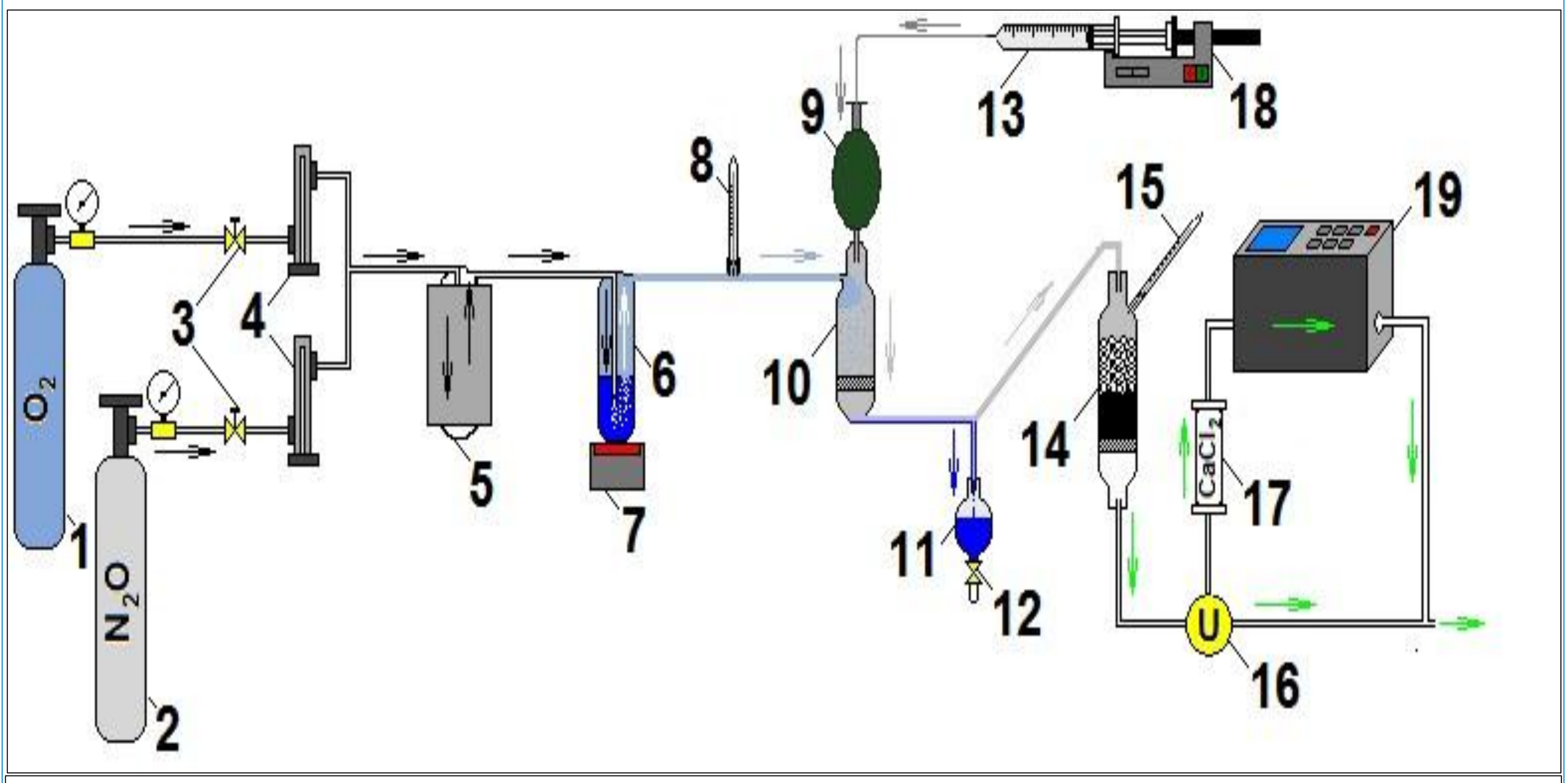
The main objective of this recent study is to characterise, evaluate and compare the adsorption behaviour of the three most recently applied anaesthetic gases (sevoflurane, isoflurane and desflurane) on different hydrophobic zeolites and multi-adsorbents using a "dynamic approach".

Materials and Methods

Commercial dealuminated USY zeolites (Z-700, TZF-1024), activated carbon and multi-adsorbents were selected for the study.

The adsorption charcteristics of the different adsorbents with respect to different halogineted ethers (flurane) have been evaluated using both dynamical gravimetric and „offline" adsorption methods. A laboratory set-up capable (Fig. 1) to simulate the condition and process of sedation using inhalational anaesthetic gases was used to measure the breakthrough curves, the pressure gradient, temperature profile and the influence of water vapour on the performance of the adsorbents under constant experimental condition (O_2 = 1 - 3 l/min, 28°C, Flurane 5,3 ml/h and 25 - 50 g adsorbent . Outlet concentration was continuously monitored by means of an Interferometer FI-21 of Riken Keiki Co., Ltd. multicomponent gas analyzer.

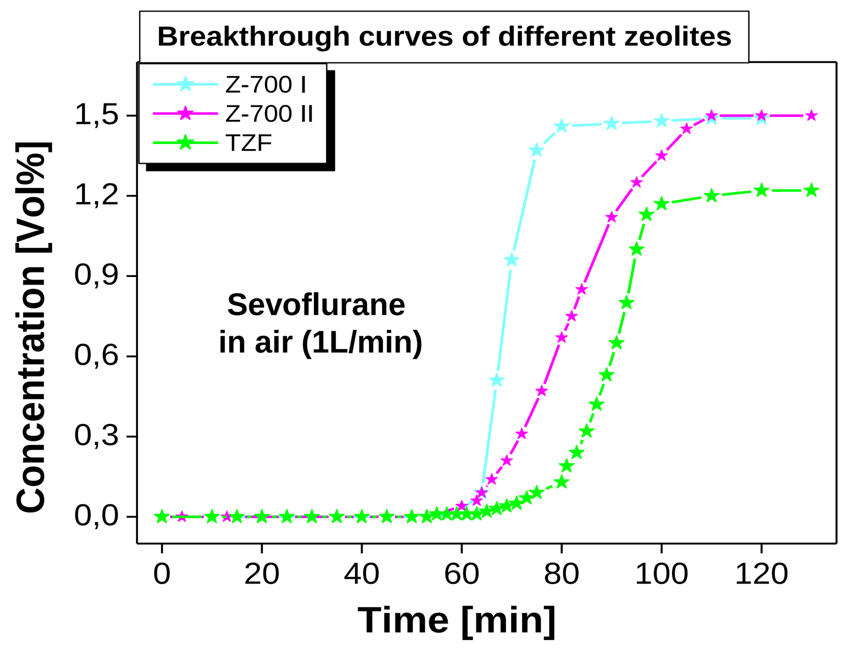
Displacement expulsion of the adsorbed gases is carried out by appling steam into the system GC/MS analysis was performed in order to find out the degree of the purity of the recovered desorbate.

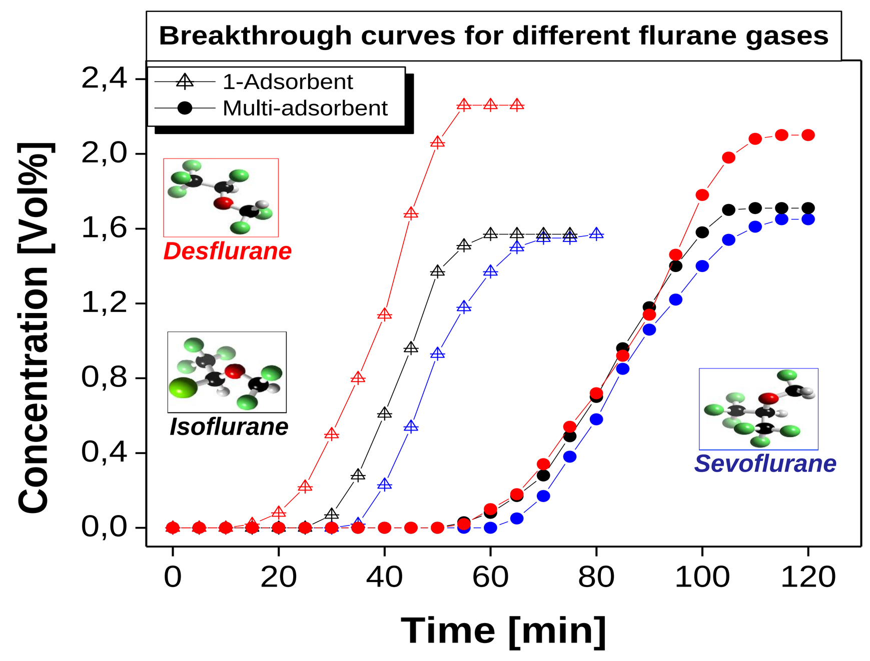


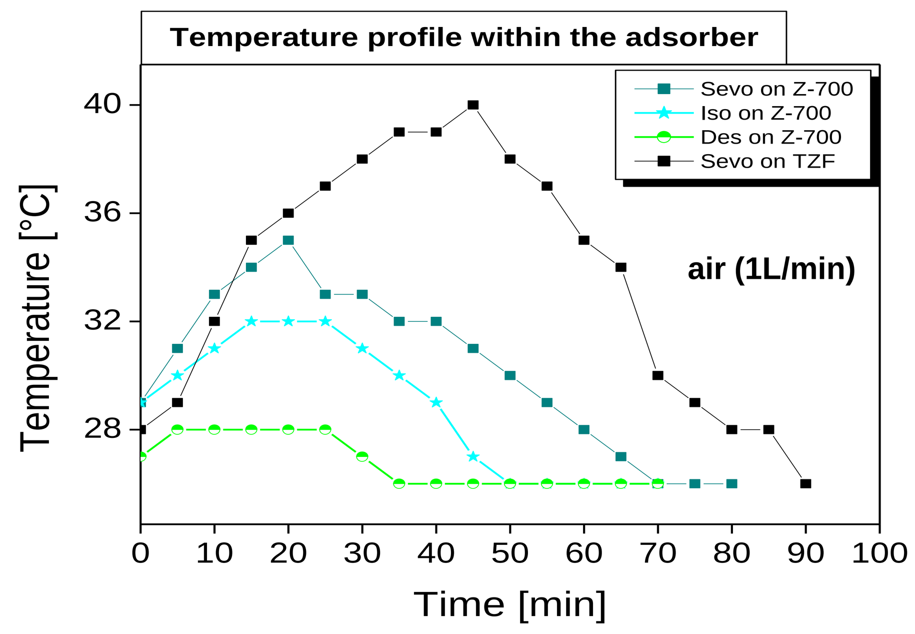
1: O_2-flask, 2: N_2O-flask, 3: gate valve, 4: Flowmeter, 5: Pre-heater
6: moistner, 7: magnetic stirrer/heater, 8: Thermometer, 9: AnaConDa, 10: Vapouriser
11: Condenser, 12: drain valve, 13 :anesthetic gas, 14: Adsorber, 15: Thermometer,
16: three-way valve, 17: Filter /$CaCl_2$, 18: Sringepump, 19: Gasanalyser

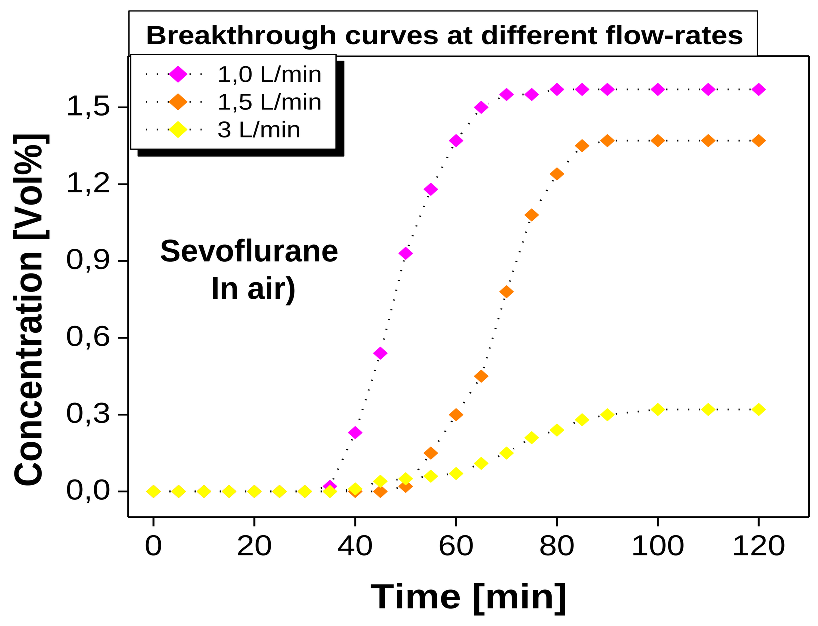
Fig. 1 : Schematic representation of the experimental setup for dynamic adsorption

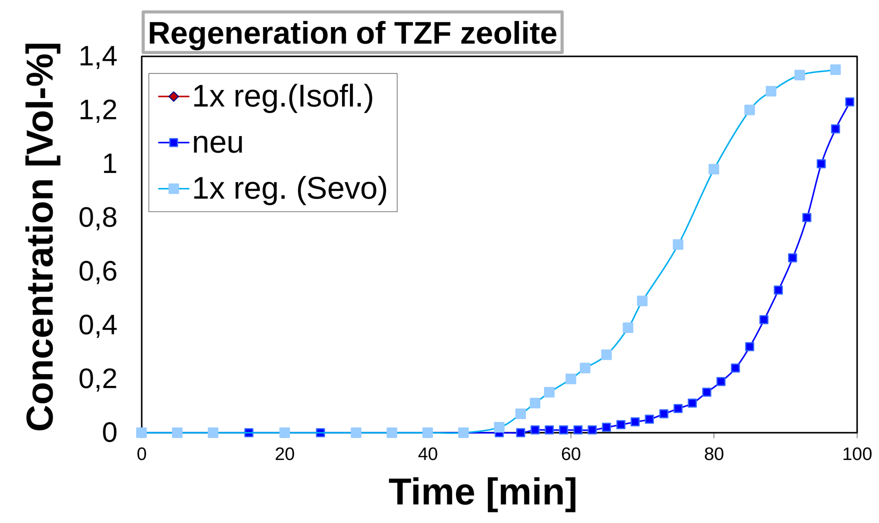
Results

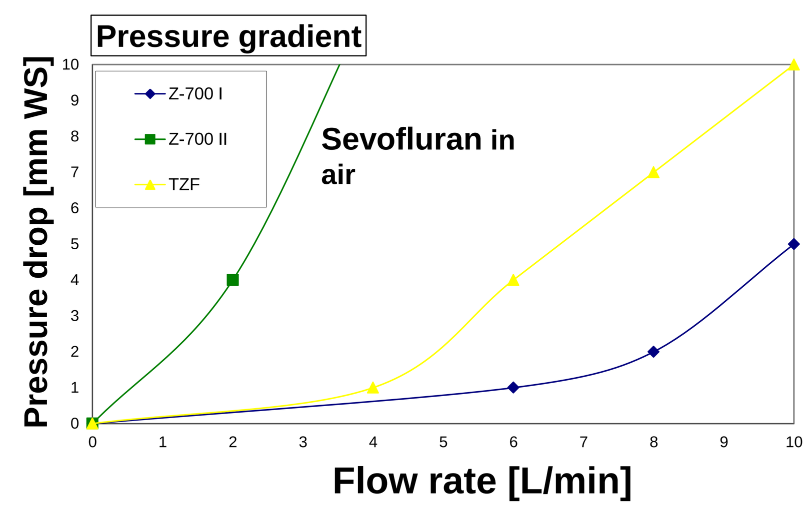












Tab. 1: Some numerical results concerning the adsorption of sevofluran

Adsorbent	Density [g/l]	Pore size [mm]	Desorbate [g]	Adsorption capacity [g/g]	Adsorption capacity [g/l]
Z-700 (I)	490	3.2 – 5	7.6 – 8.3	0.264 (0.166)	129.4 (81.3)
Z-700 (II)	550	1 – 2	8.2	0.206 (0.164)	113.3 (90.2)
TZF 1024	510	-	9.3	0.262 (0.186)	133.6 (94.9)
Multi-Adsorbent	-	-	11.1	0.530 (0.446)	238.5 (200.7)

Conclusion

- The adsorption capacity is dependent on the composition, concentration and flow rate of the applied gases and the type of adsorbent.
- A favourable adsorption characterstics, higher specific adsorption capacity, favourable breakthrough curve behaviour, low flow-resistance have been observed by applying multiple-zeolites and molecular sieve activated carbon in different ratios. This displays a complementary effect of different adsorbents on each other.
- The practical application of the technical filter-system in the operating room confirmed those results obtained from laboratory research activities.

References

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