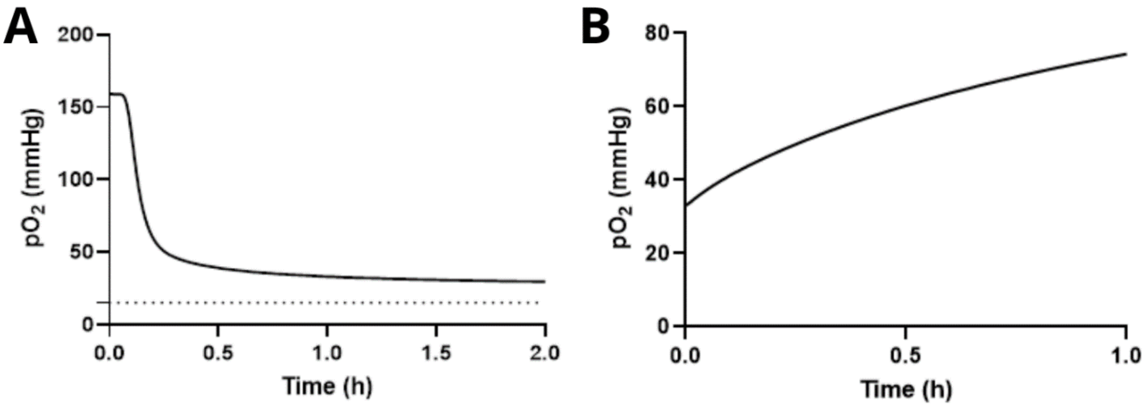


Figure S1: COMSOL simulation of a full COC chip ($D = 4.6 \times 10^{-12}$ $m^2.s^{-1}$, $S = 1.12$ $mol.m^{-3}$) with a 1mm top and bottom layer. Central channel dimensions are 3mm x 37 mm x 1 mm. Oxygen values are simulated inside the fluidic channel using a sensor positioned at the bottom center. (A) 10 µL.min^{-1} perfusion with a pre-equilibrated water at 1 5mmHg (B) Reoxygenation after cessation of the flow.

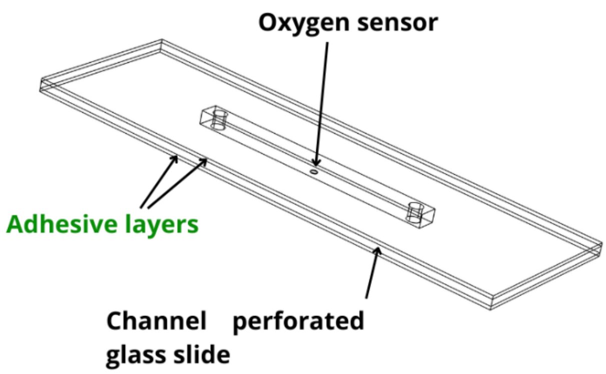


Figure S2: COMSOL model of a 3-layers chip with 2 adhesive layers and a central channel. The bottom and top glass slides are not modelized since they are considered as impermeable.

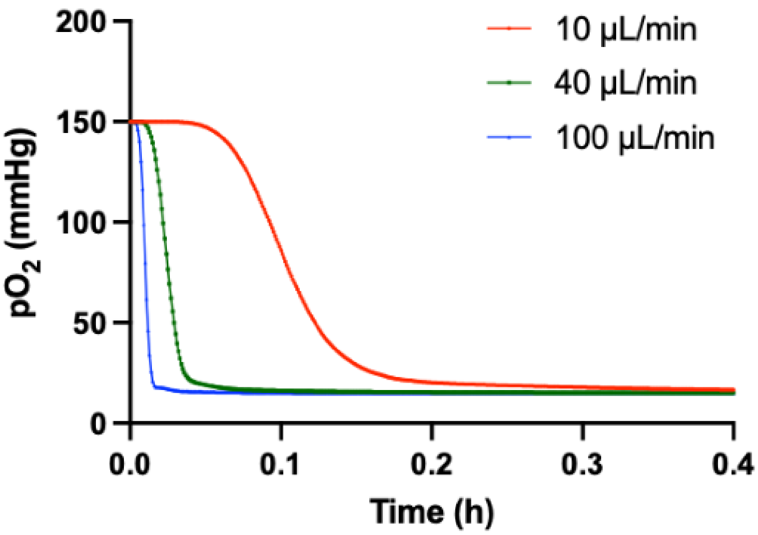
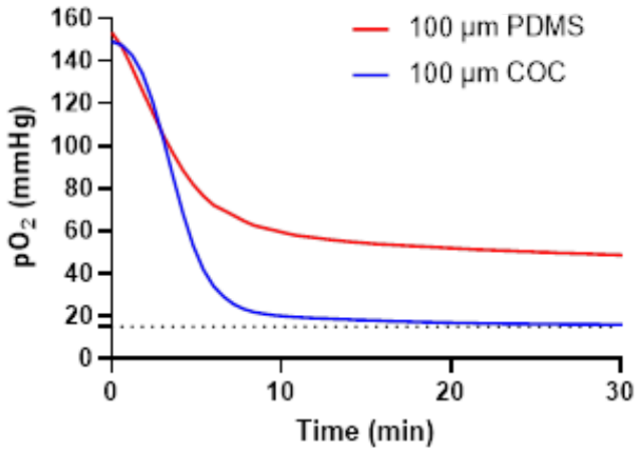
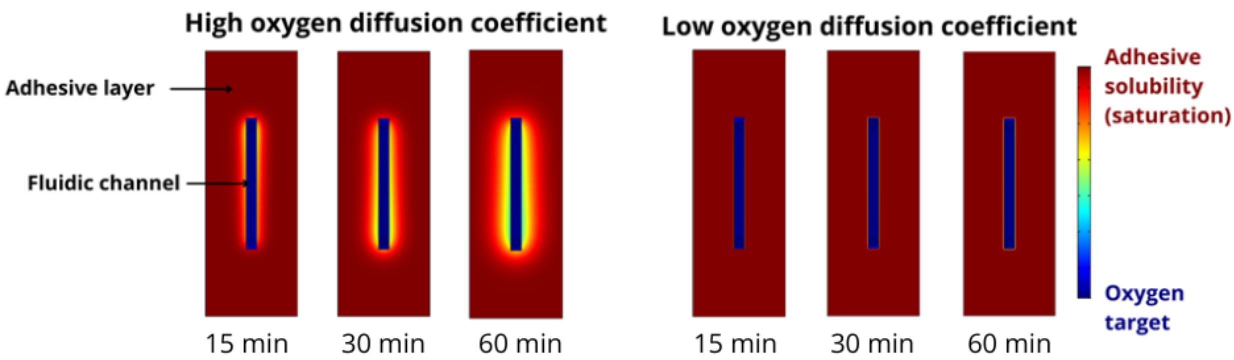


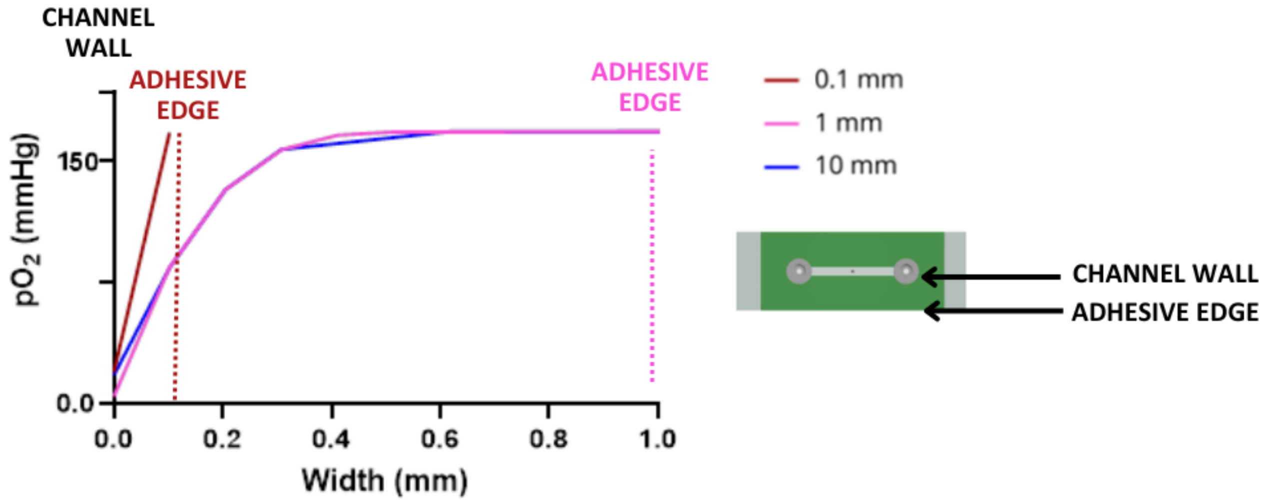
Figure S3: COMSOL simulation: perfusion time to reach the target (15 mmHg +/- 10%) in a hybrid glass-adhesive chip assembled with 100 µm of low permeability adhesive layer ($D = 4.6 \times 10^{-12}$ $m^2.s^{-1}$, $S = 1.12$ $mol.m^{-3}$ similar to COC). The adhesive *width was fully covering the glass slides (11.5 mm in x direction and 18.5 mm in y direction), perfused at a flow rate of 10 µL.min^{-1},40 µL.min^{-1} or 100 µL.min^{-1}.*



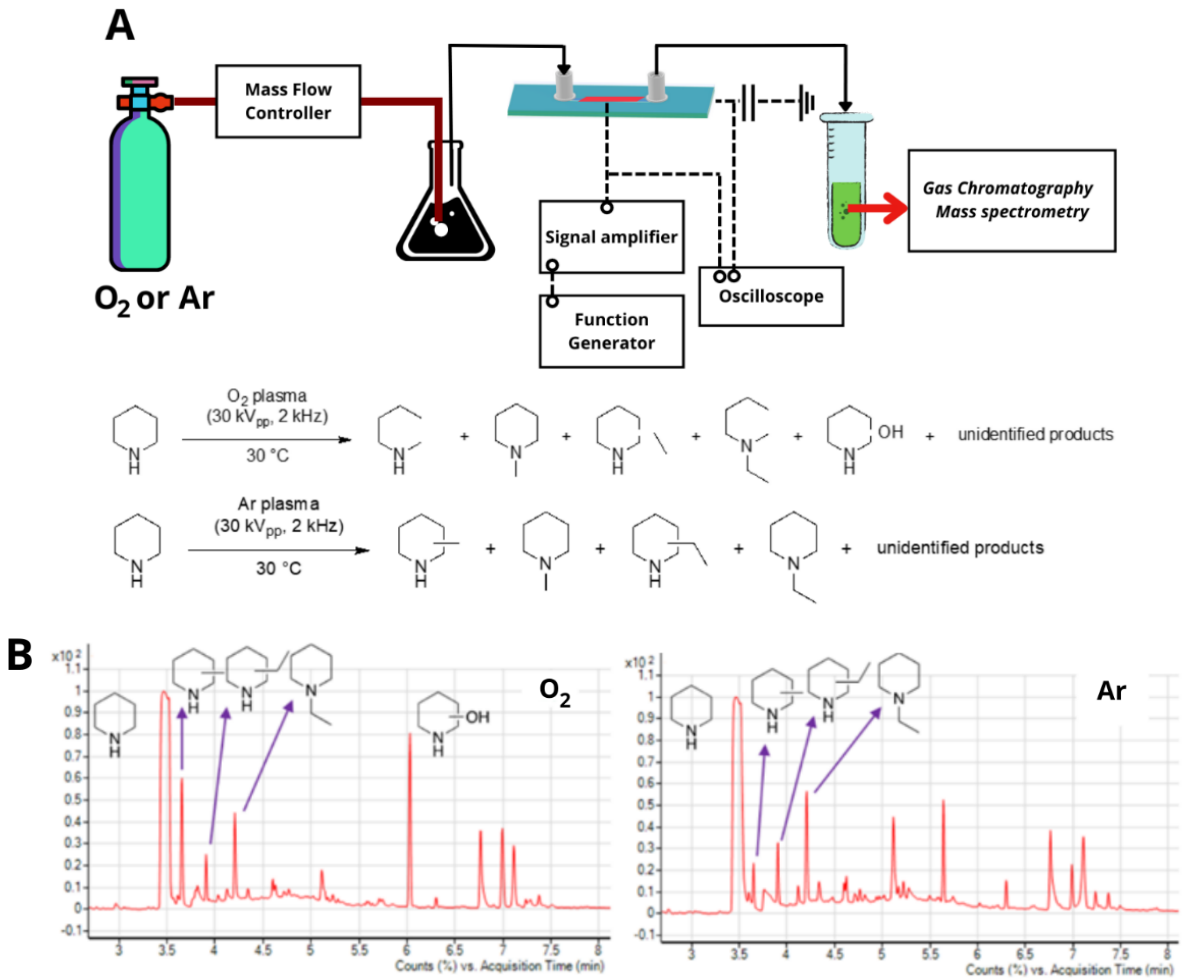
<u>Figure S4</u>: COMSOL simulation: perfusion time to reach the target in a hybrid glass-adhesive chip assembled either with 100 µm of PDMS (D = 3.4 × 10^{-9} m^2.s^{-1}, S = 1.69 mol.m^{-3}) or 100 µm of COC adhesive layer (D = 4.6 × 10^{-12} m^2.s^{-1}, S = 1.12 mol.m^{-3}), perfused at a flow rate of 10 µL.min^{-1}.



<u>Figure S5</u>: 3D COMSOL simulation in glass-adhesive chips. Different O_2 gradients are established in two different adhesive materials : (left) D = 4.6 × 10^{-12} m^2.s^{-1}, S = 1.12 mol.m^{-3} and (right) D = 3.4 × 10^{-9} m^2.s^{-1}, S = 1.69 mol.m^{-3} during the perfusion at 10 µL.min^{-1} with a pre-equilibrated water at 15 mmHg. Oxygen is depleted faster in the highly diffusive adhesive (left).



<u>Figure S6</u>: COMSOL simulation in a glass-adhesive chip: we observe an oxygen gradient within the adhesive with varying adhesive layer width (0.1 mm, 1 mm and 10 mm) and a set height of 100µm low permeability adhesive ($D = 4.6 \times 10^{-12}$ $m^2.s^{-1}$, $S = 1.12$ $mol.m^{-3}$).



<u>Figure S7</u>: (A) Experimental set-up and equations of piperidine reactions (B) GC/MS chromatograms with Argon and O_2 plasma

The gases (Ar or O_2 with a purity of 99.99%) were introduced into the chip using mass flow controllers (Bronkhorst MFC EL-FLOW prestige) at 3 $ml.min^{-1}$. Before reaching the chip, the gas stream was bubbled in a vial containing pure piperidine (liquid) maintained at 30 ºC. This was used as bubbler to enrich the carrier gas stream with the substrate (piperidine) which subsequently will be treated under plasma conditions. For this purpose, the chip was equipped with a planar copper electrode (Adhesive copper tape RS Pro ref: 176-7498) that allowed the delivery of the electrical current. A sinusoidal signal permitted the initiation of the plasma, it was delivered by an alternative function generator (AFG – sinusoidal wave at 2kHz) and amplified with a high voltage amplifier (Trek 20/20c) along with a crocodile type clamp to connect to the chip's electrode. The products formed in the gas phase were trapped using a round bottom flask filled with ethyl acetate at 0°C and the liquid phase containing trapped products was analyzed by GC/MS (Gas Chromatography coupled to Mass Spectrometry). The piperidine was treated by an Ar plasma as well as a O_2 plasma (positive control).

Precise control of oxygen levels is also pivotal in chemical processes as it can alter the formation of the final product in several types of chemical reaction [1,2]. As a proof of concept of chemical applications on-chip, a gas plasma in absence (argon plasma) or presence of oxygen (oxygen plasma) was generated in the glass-epoxy chip. The on-chip plasma was generated by ionizing a gas under an electric field creating reactive species such as electrons, ions, and radicals[3]. These species are energy vectors allowing chemical transformations.

Piperidine is an azacycloalkane i.e. a cyclohexane in which one of the carbons is replaced by a nitrogen. It was used here as a model molecule to confirm that plasma can be efficiently produced in the hybrid chip and used to induce the fragmentation of piperidine and recombination of piperidine fragments (methyl and ethyl) as previously described [4]. We first used an argon plasma assuming that the excited argon atoms and electrons can activate piperidine into piperidine radical or radical cation or piperidine fragments. We bubbled argon in a pure piperidine solution and perfused the gas enriched with piperidine in the glass-epoxy chip at $3 mL.min^{-1}$, the chip being covered with planar copper electrodes. A high voltage was then applied to produce a dielectric barrier discharge all along the channel [3]. Crude products in the gas phase were next trapped at the outlet in a flask containing ethyl acetate. This liquid phase was further analyzed by gas chromatography coupled to mass spectrometry (GC/MS). Our data demonstrated the ability of the device to be used for plasma-based chemical reaction: when piperidine was treated on-chip with Ar plasma, products formed were methyl and ethyl piperidine along with several unidentified products, as shown by GC/MS profile. We also performed similar experiments in presence of oxygen, using an oxygen plasma, we observed oxygenated products which were absent in the argon plasma. This series of experiments demonstrated the potential of this hybrid glass chip for on-chip plasma applications and opens doors for future chemical studies requiring precise oxygen control.

D_{water}	$2.5 \times 10^{-5}\ cm^2.s^{-1}$	
D_{PDMS}	$3.4 \times 10^{-5}\ cm^2.s^{-1}$	
D_{COC}	$4.6 \times 10^{-8}\ cm^2.s^{-1}$	
$[O_2]_{air}$	8.71 mol/m³	Calculated from PV=nRT
$[O_2]_{water\_eq}$	0.279mol/m³	
$[O_2]_{PDMS\_eq}$	1.69 mol/m³	
$[O_2]_{COC\_eq}$	1.125 mol/m³	
$K_{COC/water}$	4.03	Calculated: $\frac{[O_2]_{COC\_eq}}{[O_2]_{water\_eq}}$
$K_{PDMS/water}$	6.06	Calculated: $\frac{[O_2]_{PDMS\_eq}}{[O_2]_{water\_eq}}$
$K_{COC/air}$	0.129	Calculated: $\frac{[O_2]_{COC\_eq}}{[O_2]_{air}}$
$K_{PDMS/air}$	0.194	Calculated: $\frac{[O_2]_{PDMS\_eq}}{[O_2]_{air}}$

<u>Table S1:</u> Parameters used in the COMSOL simulations (diffusion, solubility and partition coefficient)

	Deoxygenation	Reoxygenation
10^{-8}	-26.5	+0.9
10^{-9}	-28.0	+0.5
10^{-10}	-29.2	+0.23
10^{-11}	-29.7	+0.08
10^{-12}	-29.8	+0.03

(mmHg/min)

<u>Table S2</u>: COMSOL simulation: Effect of different adhesive diffusion coefficient on oxygen control properties

	Deoxygenation	Reoxygenation
3	-23.6	+0.11
1.69	-27.3	+0.08
1.12	-29	+0.06
0.5	-31.2	+0.03

(mmHg/min)

<u>Table S3</u>: COMSOL simulation: Effect of different adhesive solubilities on oxygen control properties

	Deoxygenation	Reoxygenation
0.1mm	-37.4	+0.2
1mm	-37.2	+0.06
10mm	-32.8	+0.06
100mm	-19.1	+0.04

(mmHg/min)

<u>Table S4</u>: COMSOL simulation: Effect of adhesive width on oxygen control properties

	Deoxygenation	Reoxygenation
300µm	-17.8	+0.11
100µm	-29.0	+0.05
20µm	-36.7	+0.01
	(mmHg/min)	

Table S5: COMSOL simulation: Effect of adhesive thickness on oxygen control properties

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2. Baronas P, Elholm JL, Moth-Poulsen K. Efficient degassing and ppm-level oxygen monitoring flow chemistry system. *React Chem Eng*. 2023;8(8):2052-2059. doi:10.1039/d3re00109a

3. Wengler J, Ognier S, Zhang M, et al. Microfluidic chips for plasma flow chemistry: Application to controlled oxidative processes. *React Chem Eng*. 2018;3(6):930-941. doi:10.1039/c8re00122g

4. Abedelnour E, Ognier S, Zhang M, et al. Plasma flow chemistry for direct N-acylation of amines by esters. *Chemical communications*. 2022;58(52):7281-7284.