The chemical composition of Earth's atmosphere VIII: the role of the OH radical

Mole %	*Name*	*Chemical formula*	*Residence Time*	***% removed by OH***
78.084	Nitrogen	N_2	10^6-10^7 years	
20.948	Oxygen	O_2	3000-10,000 years	
0.934	Argon	Ar	Forever	
0.004 - 4	Water vapor	H_2O	~10 days	
0.0385 (385 ppm)	Carbon dioxide	CO_2	2-10 years	
0.001818 (18.18 ppm)	Neon	Ne	Forever	
0.000524 (5.24 ppm)	Helium	He	~10^6 years	
0.00017 (1.7 ppm)	Methane	CH_4	2-10 years	**90**
0.000114 (1.14 ppm)	Krypton	Kr	Forever	
0.00005 - 0.0010	Stratospheric ozone	O_3		
0.000055 (0.55 ppm)	Hydrogen	H_2	4-8 years	
0.000033 (0.33 ppm)	Nitrous oxide	N_2O	5-200 years	
0.0000050 - 0.0000200	Carbon monoxide	CO	60-200 days	**85**
0.0000087 (87 ppb)	Xenon	Xe	Forever	
0.0000010 - 0.0000500	Tropospheric ozone	O_3		
0.0000005 - 0.0000020	NMHC (Non-methane hydrocarbons)	C_xH_y		**Much***
0.0000000540 (540 ppt)	CFC12	CF_2Cl_2	>80 years	
0.00000005 (500 ppt)	Carbonyl sulfide	OCS	~ 2 years	
0.0000000265 (265 ppt)	CFC11	$CFCl_3$	~80 years	
0.00000001 - 0.000001	Hydrogen peroxide	H_2O_2	1 day	
0.00000001 - 0.0000001	Formaldehyde	CH_2O	5-10 days	
0.0000000098 (98 ppt)	Carbon tetrachloride	CCl_4	≥ decades	
0.0000000065 (65 ppt)	Methylchloroform	CH_3CCl_3	~7 years	
0.000000001 - 0.0001	Nitrogen oxides	NO_x	A few days	**Much***
0.000000001 - 0.0000001	Ammonia	NH_3	A few days	
0.000000001 - 0.0000001	Sulfur dioxide	SO_2	hours to weeks	**30**
0.000000001 - 0.00000001	Dimethyl sulfide	CH_3SCH_3	<1 day	**90**
0.0000000001 - 0.00000003	Carbon disulfide	CS_2	~40 days	
0.0000000005 - 0.00000005	Hydrogen sulfide	H_2S	<5 days	
0.0000000002 (2 ppt)	Hydroperoxyl radical	HO_2		
0.000000000005 (0.05 ppt)	**Hydroxyl radical**	**OH**	**≤ a few seconds**	

*90% of C_2H_6

*50% of NO_2

As we noted in the previous page of this series, the unpaired electron of an OH radical makes OH a very reactive chemical entity. Specifically, it's very ready to grab an electron from somewhere to pair with its unpaired electron, and thus to achieve a full outer shell. That means that OH agressively oxidizes not-fully-oxidized chemical components of the atmosphere.

The results of that agressive oxidation can be seen in the table at left. The new rightmost column shows that oxidation by OH removes large proportions of the not-fully oxidized C-, N-, and S- bearing species (and it probably removes non-trivial proportions of similar species for which there is no entry in the right hand column). Oxidation by OH thus significantly controls the composition of the atmosphere, because the minor not-fully-oxidized components of our atmosphere would accumulate to be major components of an atmosphere without OH (where oxidation of the not-fully-oxidized components would have to await the action of the much more sluggish O_2 molecule).

The flip side of this relationship is that rapid and abundant reactions remove OH from the atmosphere, so that it has a very small concentration and very short residence time. Those small numbers, rather than suggesting that OH is insignificant, reflect how active and critical OH is in controling the compositionof the atmosphere.

Sources: see Part I of this series. The "% removed by OH" column, and many of the concepts here, are from Prinn (2003).