



Dipartimento di Scienze
Cardio-Toraco-Vascolari
e Sanità pubblica



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

Glyoxal Acid-Free (GAF) a non-toxic alternative to formalin for fixation in Forensic Science

Dr. Matteo Perilli¹, Dr. Michela Gastaldi², Prof. Massimo Montisci¹

1. Department of Cardio-Thoraco-Vascular Sciences and Public Health (DCTV) – University of Padua;
2. Addax Biosciences s.r.l., Torino





Declaration of Absence of Conflict of Interest

I declare under my responsibility that **there is no conflict of interest** that may compromise my impartiality and independence.

I also declare that **I have no economic, professional, or personal relationships with parties that could influence my ability to act objectively and transparently.**



Formaldehyde – History of its use in medicine



1761

«*De sedibus et causis morborum per anatomen indagatis*» - G.B. Morgagni

Pathological anatomy is born



1838

"*Cell theory*"
Matthias Jacob Schleiden
Theodor Schwann.



1859

Discovery of Formaldehyde
Aleksandr Butlerov

Formaldehyde – History of its use in medicine



1859

Discovery of Formaldehyde
by Aleksandr Butlerov



1889

Start of industrial production in Germany
and use in medicine as a fixative and
disinfectant



Why an alternative?



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Why an alternative?



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History of Formaldehyde

Aleksandr Butlerov

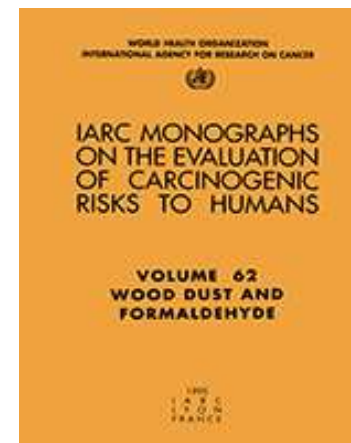


1889

Start of industrial production in Germany
and use in medicine as a fixative and
disinfectant

Country (refers to) Population, design and duration	Exposure assessment	Cancer	Relative risk (95% CI)	Comments
United Kingdom (Gill et al., 1981) (Hepburn et al., 1986) (all members since 1975)	Pathologists, SMR (4312), 1974-87	None All causes Colo. All lung Brain Lymphatic/hematopoietic Leukemia Breast	0.64 (0.4-0.8) 1.04 (0.8-1.2) 0.51 (0.4-0.6) 0.23 (0.1-0.4) 0.25 (0.1-0.5) 1.04 (0.7-1.3) 1.25 (0.9-1.9) 1.6 (0.4-6.4)	194 deaths 59 deaths Seven deaths Nine deaths Six deaths 10 deaths Four deaths Four deaths among women
New York, USA (Choi et al., 1992a) (Eisen et al., 1992b)	Emtchems, PMR, PCMR (1312 cases, 1925-80)	None Basal/squamous	1.1 (0.6-1.9) 3.3 (0.4-1.2)	243 deaths Eight deaths among men in Scotland
		Colo. Long Brain	2.0 (0.8-5.1) 1.3 (0.9-1.9) 2.1 (0.9-4.7)	Eight deaths, PCMR Pathologists only, seven deaths, PMR 78 deaths, PMR
		Leukemia	1.4 (0.6-3.7)	29 deaths, PCMR
		Lymphoma	2.1 (0.8-5.1)	78 deaths, PMR
		Prostate	0.9 (0.2-2.7)	None deaths, PMR
		Bladder	1.2 (0.4-3.6)	Eight deaths only, six deaths, PMR
		Stomach	0.9 (0.2-2.7)	Pathologist diagnoses, three deaths, PMR
		Leukemia	1.2 (0.4-3.6)	23 deaths, PMR
		Lymphoma	0.8 (0.3-1.9)	Free deaths, PMR
		Prostate	1.2 (0.6-2.1)	12 deaths, PCMR
California, USA (Choi et al., 1992b)	Emtchems, PMR, PCMR (1007 white men, 1925-80)	Diverse Basal/squamous	1.3 (0.6-2.6) 1.3 (0.6-2.6)	201 deaths Eight deaths, PMR, inverse trend with duration
		Colo.	1.4 (0.9-2.0)	34 deaths, PCMR, no trend
		Long	0.9 (0.6-1.2)	41 deaths, PCMR, no trend
		Brain	0.6 (0.4-0.9)	6 deaths
		Prostate	1.3 (0.8-2.0)	23 deaths, PCMR, no trend
		Bladder	1.3 (0.8-2.0)	None deaths, PMR, no trend
		Lymphatic/hematopoietic	1.2 (0.5-1.9)	19 deaths, PMR
		Lymphoma	1.0 (0.7-1.4)	Three deaths, PMR
		Leukemia	1.4 (0.7-2.4)	12 deaths, PMR, trend with duration

Canada (Gosselin et al., 1986a)	Embryos, SMR (1477 men, 1950-77)	None	All causes All cancers Neoplasm Buccal pharynx Long Brain Prostate Lymphatic/hematopoietic Leukemia	1.0 (0.9-1.1) 0.9 (0.7-1.1) — 0.5 (NA) 0.9 (0.4-1.5) 1.2 (0.2-2.4) 1.0 (0.2-2.6) 1.2 (0.5-2.6) 1.1 (0.4-4.1)	319 deaths 12 deaths (2 expected) One death 19 deaths Three deaths Three deaths Eight deaths Four deaths	USA (Lippert et al., 1988)	Pathologists, SMR (5185 men, 1962-77)	None	Buccal pharynx Digestive organs Respiratory system Lymphatic/hematopoietic Leukemia	0.7 (NA) 0.8 (NA) 0.2 (p < 0.01) 0.5 (0.0-1) 1.1 (NA)	900 deaths among white men 192 deaths among nonwhite men 20 deaths among white men Four deaths among nonwhite men Three deaths among white men One death among nonwhite men 99 deaths among white men 16 deaths among nonwhite men 14 deaths among white and nonwhite men
USA (Hiro et al., 1988)	Anatomists, SMR (2239 men, 1925-79)	Duration	All causes All cancers Buccal pharynx Colon Cervix Nasal Long Prostate Brain Lymphatic/hematopoietic Lymphoma Leukemia Other lymphatic tissue	0.7 (0.4-0.8) 0.7 (0.4-0.8) 0.2 (0.0-0.6) 1.1 (0.5-1.7) 0.8 (0-1.2) 0.3 (0.0-1.5) 1.0 (0.5-1.6) 2.7 (1.5-5.0) 1.2 (0.7-2.0) 0.7 (0.1-2.5) 1.5 (0.7-2.7) 2.5 (0.7-4.4)	718 deaths 118 deaths One death 20 deaths 10 deaths, 5 expected 16 deaths, no trend with duration 19 deaths 16 deaths, trend with duration 14 deaths Two deaths 10 deaths Six deaths	USA (Gosselin et al., 1989)	Embryos, PMR (3649 white men, 397 nonwhite men), 1975-83	None	All causes Buccal pharynx Neoplasms Colon Cervix Nasal Long Prostate Brain Lymphatic/hematopoietic Lymphoma Leukemia	1.1 (1.0-1.2) 1.0 (0.9-1.1) 1.3 (0.9-1.7) 1.0 (0.9-1.2) 1.9 (0.4-5.1) 4.0 (0.1-32) 1.2 (0.1-1.4) 2.3 (1-3.8) 1.0 (0.9-1.1) 0.8 (0.5-1.1) 1.1 (0.9-1.3) 1.4 (0.9-2.1) 1.2 (0.8-1.8)	992 deaths among white men 182 deaths among nonwhite men 20 deaths among white men Four deaths among nonwhite men Three deaths among white men One death among nonwhite men 99 deaths among white men 16 deaths among nonwhite men 14 deaths among white and nonwhite men 285 deaths among white men 21 deaths among nonwhite men 79 deaths among white men 19 deaths among white men 24 deaths among white men 0 deaths among nonwhite men 100 deaths among white men 15 deaths among nonwhite men 11 deaths among white men One death among nonwhite men Five deaths among white men Two deaths among nonwhite men 11 deaths among white men One death among white men One death among nonwhite men
USA (Lippert et al., 1988)	Pathologists, SMR (5185 men, 1962-77)	None	Buccal pharynx Digestive organs Respiratory system Lymphatic/hematopoietic Leukemia	0.7 (NA) 0.4 (NA) 0.2 (p < 0.01) 0.5 (NA) 1.1 (NA)	— One death One death One death One death	California, USA (Gosselin et al., 1989)	Embryos, PMR (3649 white men, 397 nonwhite men), 1975-83	None	All causes Buccal pharynx Neoplasms Colon Cervix Nasal	1.1 (1.0-1.2) 1.1 (0.9-1.3) 1.2 (0.8-1.7) 1.0 (0.5-1.2) 1.9 (0.4-5.1) 4.0 (0.1-32) 1.2 (0.1-1.4) 2.3 (1-3.8)	900 deaths among white men 182 deaths among nonwhite men 20 deaths among white men Four deaths among nonwhite men Three deaths among white men One death among nonwhite men 99 deaths among white men 16 deaths among nonwhite men 14 deaths among white and nonwhite men
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California, USA (Gosselin et al., 1989)	Pathologists, SMR (5185 men, 1962-77)	None	Buccal pharynx Digestive organs Respiratory system Lymphatic/hematopoietic Leukemia	0.7 (NA) 0.4 (NA) 0.2 (p < 0.01) 0.5 (NA) 1.1 (NA)	— One death One death One death One death	California, USA (Gosselin et al., 1989)	Embryos, PMR (3649 white men, 397 nonwhite men), 1975-83	None	All causes Buccal pharynx Neoplasms Colon Cervix Nasal	1.1 (1.0-1.2) 1.1 (0.9-1.3) 1.2 (0.8-1.7) 1.0 (0.5-1.2) 1.9 (0.4-5.1) 4.0 (0.1-32) 1.2 (0.1-1.4) 2.3 (1-3.8)	900 deaths among white men 182 deaths among nonwhite men 20 deaths among white men Four deaths among nonwhite men Three deaths among white men One death among nonwhite men 99 deaths among white men 16 deaths among nonwhite men 14 deaths among white and nonwhite men
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Why an alternative?



1859

Discovery of Formaldehyde
by Aleksandr Butlerov



1889

Start of industrial production in Germany
and use in medicine as a fixative and
disinfectant

INAIL
**ESPOSIZIONE OCCUPAZIONALE
A FORMALDEIDE IN LABORATORI
DI ANATOMIA PATOLOGICA**

INTRODUZIONE
La formaldeide, uno dei composti organici volatili (COV) più diffusi, è un gas incolore ed irritante, in passato commercializzato sotto forma di soluzione acquosa (al 35-40%) detta formalina e utilizzata a fini di sanificazione e materiale organico. Presente in natura come prodotto del metabolismo dei sistemi viventi, le principali fonti espositive per la popolazione generale sono i processi di combustione, il fumo, le vernici, alcuni tipi di colle, i tessuti, alcuni alimenti o in particolare i cibi affumicati. L'utilizzo della formaldeide di maggior rilievo è oggi nell'industria dei polimeri, nell'industria del legno che viene trattato con resine a base di una formaldeide, nelle sintesi delle materie plastiche e come biocida. Nel comparto sanitario, è ampiamente utilizzata a tutt'oggi nelle operazioni di allestimento di preparati istologici e nelle attività funerarie.

2022
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EFFETTI SULL'UOMO
Questo composto è altamente reattivo, molto solubile in acqua e facilmente assimilabile dal corpo umano. L'esposizione più significativa è quella inalatoria; il 90% circa di formaldeide zero-dispersa viene assorbita dal tratto respiratorio superiore (World Health Organization, WHO 2010) [1] inducendo irritazione delle mucose, degli occhi, della gola e del tratto respiratorio. Secondo la classificazione ed etichettatura armonizzata approvata dall'Unione Europea [2] la formaldeide è cancerogena di categoria 1B, mutagena di categoria 2 e tossica per tossicità acuta di categoria 3. L'International Agency for Research on Cancer (IARC) già nel 2006 [3], la classifica cancerogena certo per l'uomo (Gruppo 1). Successivi approfondimenti (monografia ILOF del 2012) confermano tale classificazione sulla base di urtvidenza epidemiologica sufficiente per tumori della rinfaringe e leucemia.

VALORI LIMITE PER L'ESPOSIZIONE PROFESSIONALE
Le agenzie internazionali hanno fissato i valori limite per l'esposizione occupazionale riportati in Tabella 1. Nel 2019 l'Europa ha emanato la Direttiva EU 2019/983 (recepta in Italia dal d.m. 11/02/2021), che sulla base delle raccomandazioni dello SCOEL (Scientific Committee on Occupational Exposure Limits) modifica la precedente (Direttiva 2004/37/EC) sulla protezione dei lavoratori contro i rischi derivanti dall'esposizione ad agenti cancerogeni e mutageni durante il lavoro, introduce limiti più stringenti ed inserisce una nota relativa alla sensibilizzazione cutanea. Insieme ai provvedimenti della Direttiva UE 2019/130, queste disposizioni aggiornano e sostituiscono gli Allegati XLII e XLIII del d.lgs. 81/2008. La sorveglianza sanitaria per i lavoratori potenzialmente esposti ed in ordine non solo al suo potenziale cancerogeno, ma anche per i suoi effetti irritativi e sensibilizzanti, in applicazione dell'art. 229 del d.lgs. 81/2008.

Tabella 1

Ente	Limite di esposizione	Valori limite d'esposizione Misura in relazione al periodo di riferimento
SCOEL Europa (Direttiva UE-98/3/2019)	0,3 ppm (0,37 mg/m ³) 0,5 ppm (0,62 mg/m ³)* 0,6 ppm (0,74 mg/m ³)	CEL-TWA-8h CEL-STEL 15min (effetti irritativi acuti)
ACGIH (American Conference of Governmental Industrial Hygienists) (2017)	0,1 ppm (0,12 mg/m ³) 0,3 ppm (0,37 mg/m ³)	TLV-TWA-8h TLV-STEL 15 min
NIOSH (National Institute for Occupational Safety and Health)	0,016 ppm (0,02 mg/m ³) 0,1 ppm (0,12 mg/m ³)	REL-TWA (recommended exposure limit) TLV-Ceiling 15min exposure limit
OSHA (Occupational Safety and Health Administration)	0,75 ppm (0,92 mg/m ³) 2 ppm (2,46 mg/m ³)	PEL-TWA 8h (Permissible Exposure Limit)

* Transitorio di 5 anni (fino all'11 luglio 2024) per i settori sanitario, funerario e dell'imbalsamazione

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USO IN ANATOMIA PATOLOGICA
Nonostante le possibili alternative indicate dalla letteratura scientifica (alcol etilico al 70% tamponato con tampone fosfato, glutaraldeide, acido acetico al 5%, acido picrico), nel comparto sanitario la formaldeide rimane il fissativo più utilizzato nelle operazioni di allestimento di preparati istologici. La fissazione non è un processo semplice; impiega dalle 24-48 ore a seconda della grandezza del frammento e consiste nel trattare il tessuto, con procedimenti chimici o fisici a seconda della specificità dell'esame. La soluzione acquosa di formaldeide, ottimo fissativo, economico e versatile, permette di svolgere diversi esami diagnostici e trova ampio uso non solo nella fissazione dei tessuti in anatomia patologica, in quanto efficace nel mantenere inalterata la morfologia cellulare, ma anche nella conservazione e nel trasporto di materiali biologici prelevati nelle sale operatorie e negli ambulatori di prelievo biopsico (endoscopico, radiologico ecc.) durante gli interventi chirurgici e le biopsie. La formaldeide è anche usata per il trattamento conservativo di salme che devono essere trasportate a distanza e nelle attività di imbalsamazione. Diverse sono quindi le figure potenzialmente esposte, dal personale medico in sala operatoria a chi opera sui campioni biologici in laboratorio, fino a tutto il personale coinvolto nel processo di conservazione, archiviazione e smaltimento degli stessi. Diversi i punti critici e i fattori che possono influenzare l'esposizione:

- raccolta, trasporto, tracciabilità e archiviazione del campione;
- concentrazione della soluzione di formaldeide;
- dimensione e numero di parti anatomiche da processare;
- metodo e numero di postazioni di lavoro nella stessa stanza;
- dimensioni dei locali;
- tipo ed efficienza delle cappe e dei sistemi di ventilazione.

PREVENIRE E RIDURRE L'ESPOSIZIONE
La gestione dell'esposizione a formaldeide si avvale di molteplici soluzioni, che non riguardano solo l'uso di dispositivi di protezione individuale e collettiva, ma anche di disposizioni tecniche che possano in ogni fase ridurre al minimo l'esposizione. L'obiettivo primario è ridurre o limitarne l'uso e ove questo non sia possibile, servirsi di tutte le soluzioni idonee a ridurre il rischio di esposizione, che vanno dall'uso di dispositivi di protezione individuale adeguati, fino all'impiego di contenitori sotto vuoto o muniti di tappi a tenuta per le possibili fuoriuscite di vapori, e all'uso di temperature basse e controllate sia durante il trasporto che durante lo stazionamento dei contenitori in sala operatoria e in laboratorio. Esistono contenitori di sicurezza per la gestione di piccoli campioni istologici nei quali la formalina è contenuta in capsula sigillata e solo dopo aver introdotto il campione biopsico all'interno della base (vuota), è possibile erogare la formaldeide. Adottare misure organizzative adeguate: il materiale biologico che giunge presso il laboratorio di anatomia patologica, deve essere trattato per quanto possibile a fresco, in un'adeguata postazione che abbia una cappa biohazard, al fine di tutelare non solo l'operatore ma anche l'ambiente circostante. I locali in cui si gestisce la formalina devono essere forniti di adeguati ricambi d'aria. Apertura delle finestre è spesso la soluzione più frequente, ma l'uso della ventilazione forzata o di deumidificatori d'aria con filtri specifici, è sicuramente più efficace a garantire la salubrità di tutto l'ambiente. In caso di sversamenti accidentali, è necessario indicare una specifica procedura che individui i dispositivi individuali e gli strumenti da adottare per la rimozione in sicurezza del materiale versato al fine di riportare l'ambiente in sicurezza. Inoltre si ricordano, ai sensi del d.lgs. 81/2008, la necessità di limitare al minimo possibile il numero dei lavoratori esposti, di effettuare le misurazioni della formaldeide aerodispersa, di svolgere la formazione e informazione dei lavoratori, la sorveglianza sanitaria e l'iscrizione dei lavoratori esposti nel registro degli esposti a cancerogeni.

PER ULTERIORI INFORMAZIONI
Contatti: e.barrese@inail.it; m.scarpelli@inail.it; g.tranfolini@inail.it

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[1] World Health Organization. Formaldehyde. In: Selected pollutants. WHO Guidelines for Indoor Air Quality. WHO, Regional Office for Europe, Copenhagen, Denmark; 2010 (pp.103-166).
[2] <https://echa.europa.eu> (consultato marzo 2022).
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PAROLE CHIAVE
Esposizione occupazionale; Formaldeide; Anatomia Patologica

Inail - Dipartimento di medicina, epidemiologia, igiene del lavoro e ambientale - Direttore: Stefano Signorini
Via Fontana Candida, 1 - 00078 Monte Porzio Catone (RM)
Tel. 06 941 81 405 - 404 - Fax 06 941 81 419 - dmin@inail.it





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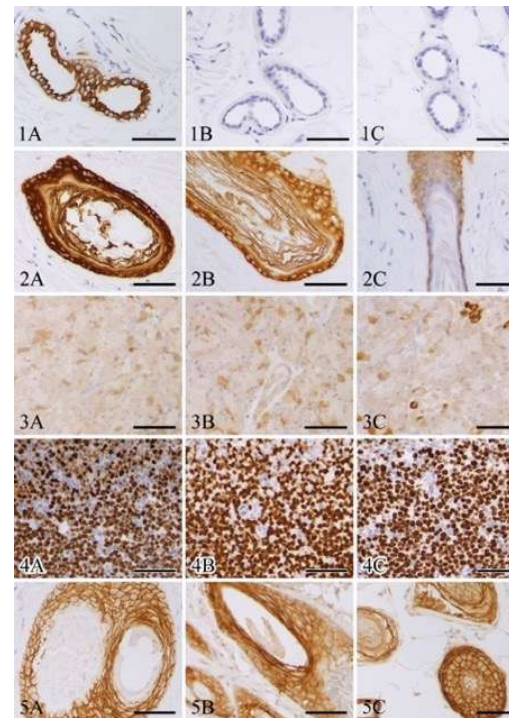
1859

Discovery of Formaldehyde
by Aleksandr Butlerov



1889

Start of industrial production in Germany
and use in medicine as a fixative and
disinfectant



1 day

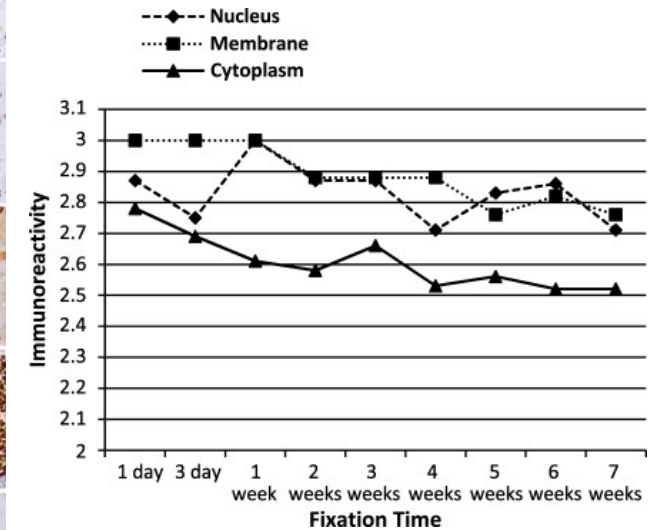
3 days

7 days

Journal of Histochemistry & Cytochemistry **JHC**

Effects of Prolonged Formalin Fixation on Diagnostic Immunohistochemistry in Domestic Animals

[Joshua D Webster](#)¹, [Margaret A Miller](#)¹, [Dee DuSold](#)¹, [José Ramos-Vara](#)¹



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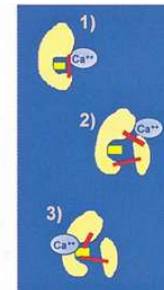
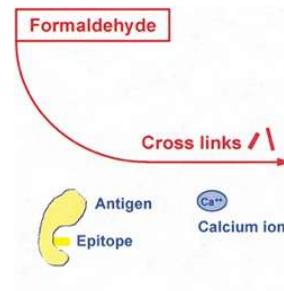
ORIGINAL ARTICLES

Effect of Formalin Tissue Fixation and Processing on Immunohistochemistry

Werner, Martin M.D.; Chott, Andreas M.D.; Fabiano, Alfredo M.D.; Battifora, Hector M.D.

[Author Information](#)

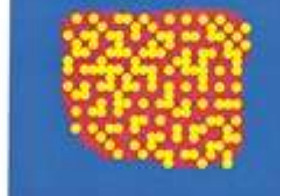
The American Journal of Surgical Pathology 24(7):p 1016-1019, July 2000.



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24 h



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by Joseph L. Davis



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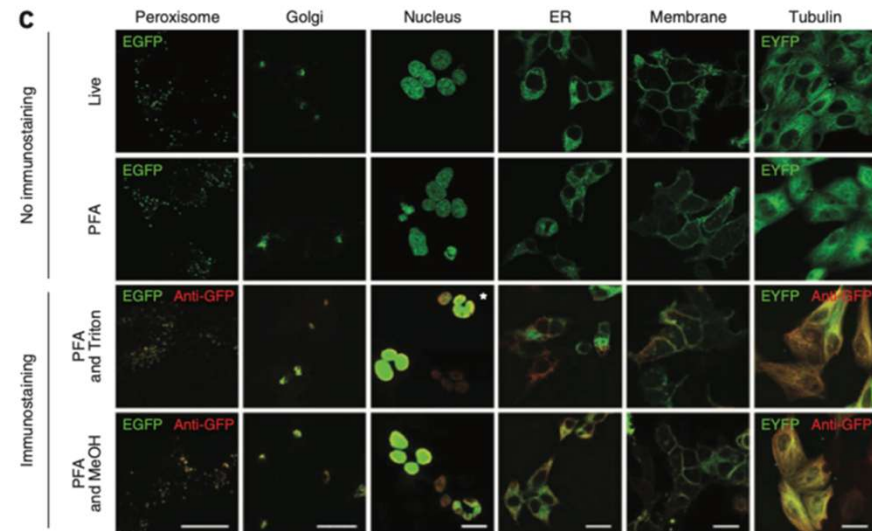


nature methods

Perspective | Published: 30 January 2012

Immunolabeling artifacts and the need for live-cell imaging

[Ulrike Schnell](#), [Freark Dijk](#), [Klaas A Sjollema](#) & [Ben N G Giepmans](#)



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Discovery of Formaldehyde
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But... Is there a valid one?





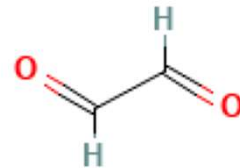
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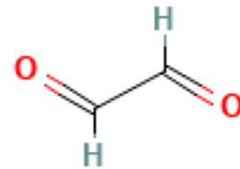


Glyoxal





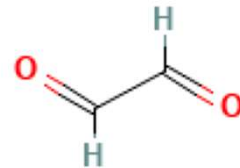
Glyoxal



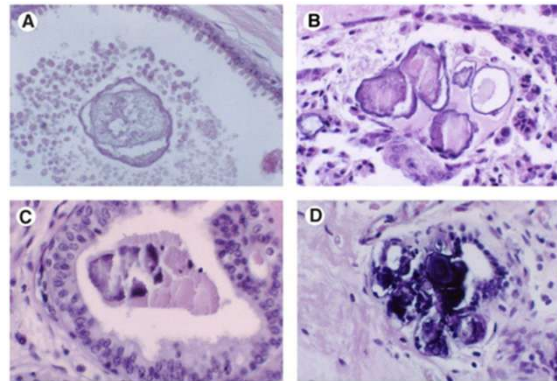
The **smallest dialdehyde**. It's an ethane having oxo-groups on both carbons.



Glyoxal



Proposed as an alternative to formalin in **1943**.
It is not volatile in its aqueous phase and **is not carcinogenic** to humans.



2004

Comparative studies show loss of cellular details,
erythrocyte lysis and dissolution of
microcalcifications in solutions with Glyoxal. In
addition, the results of '*in situ*' hybridisation and gene
sequencing appeared to be compromised.



Acid-free glyoxal as a substitute of formalin for structural and molecular preservation in tissue samples

[Gianni Bussolati](#)¹, [Laura Annaratone](#)¹, [Enrico Berrino](#)², [Umberto Miglio](#)², [Mara Panero](#)², [Marco Cupo](#)¹,
[Patrizia Gugliotta](#)¹, [Tiziana Venesio](#)², [Anna Sapino](#)^{1,2}, [Caterina Marchiò](#)^{1,3,*}

2017

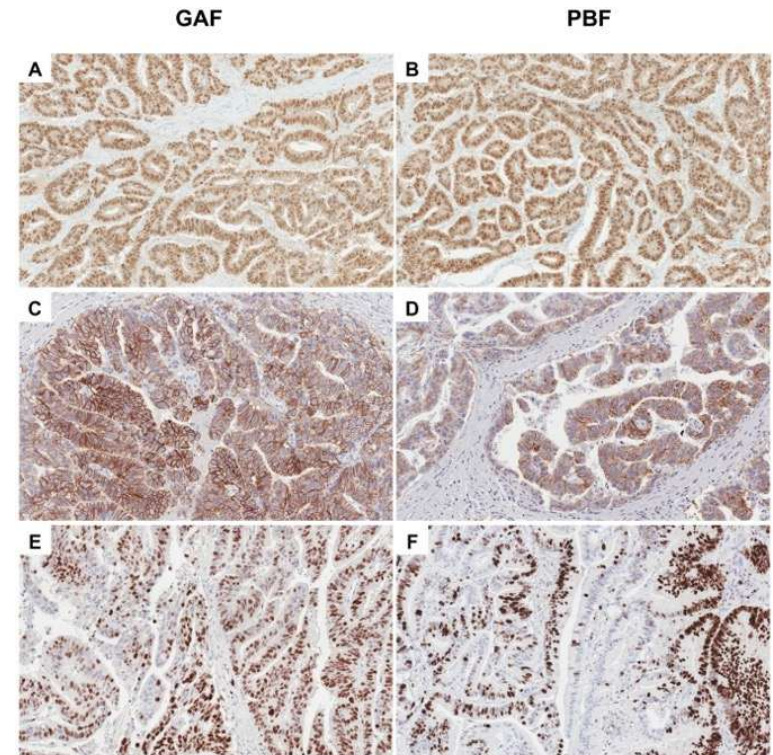
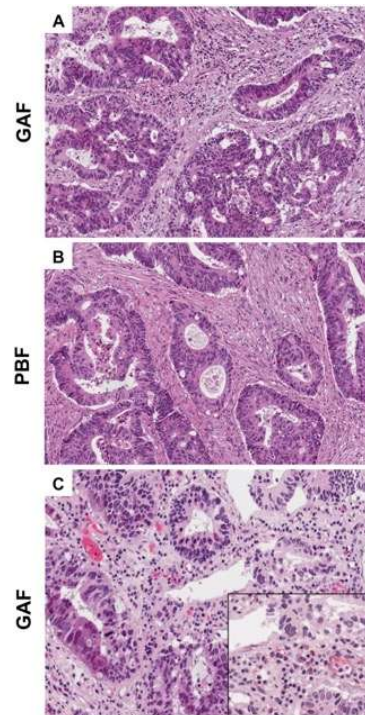
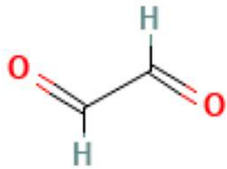
Assuming that these effects are due to the action of the acid component of the solution, in 2017 Bussolati et al. produced a solution buffered with resins. **The Acid-Free Glyoxal is born**



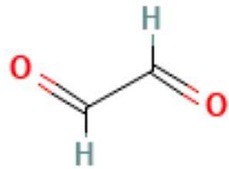
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Acid-Free Glyoxal

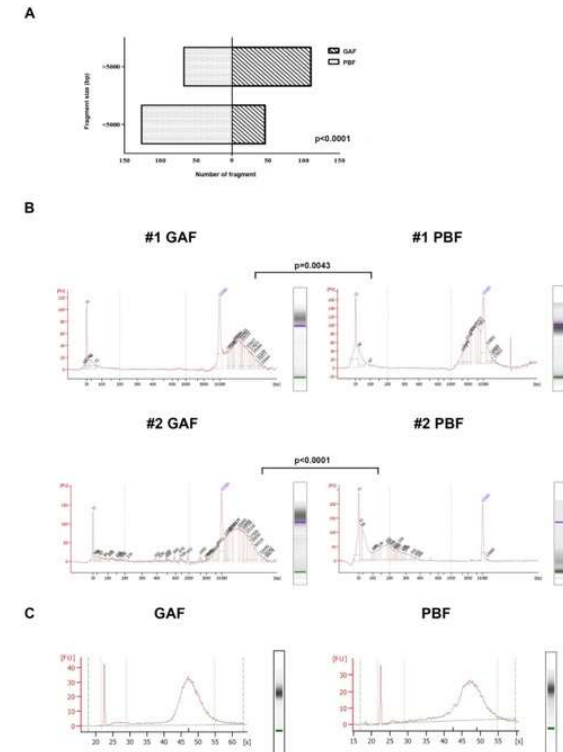
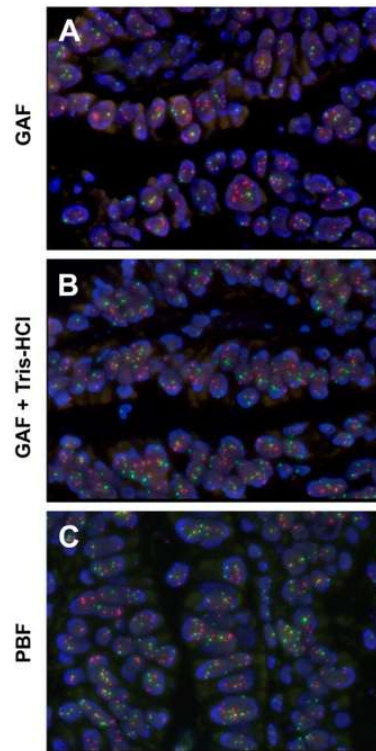


Acid-Free Glyoxal



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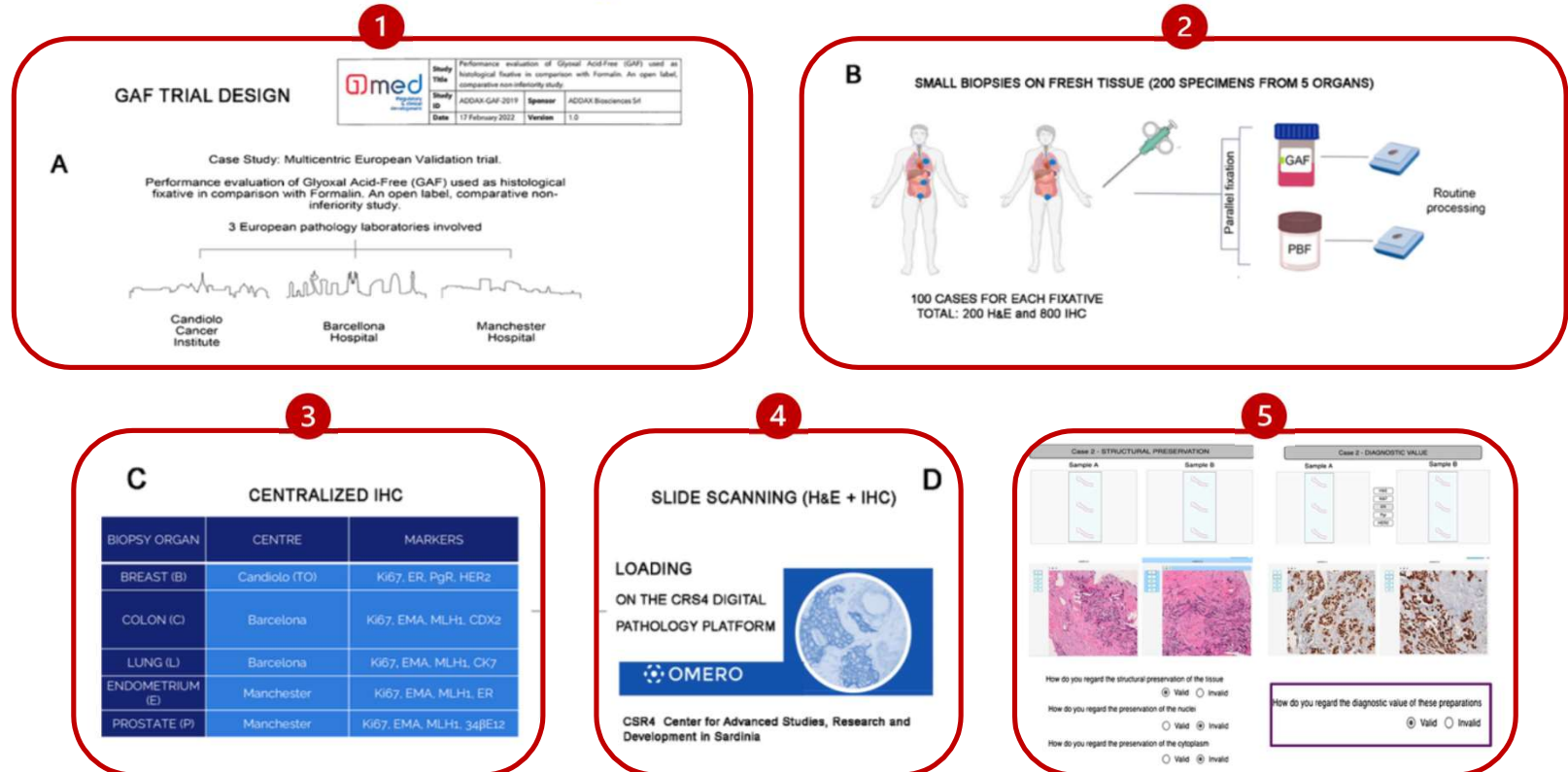
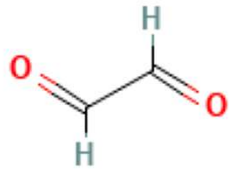




Glyoxal acid-free (GAF) histological fixative is a suitable alternative to formalin: results from an open-label comparative non-inferiority study

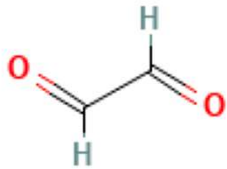
Ales Ryska¹ · Anna Sapino^{2,3} · Stefania Landolfi⁴ · Irene Sansano Valero⁴ · Santiago Ramon y Cajal⁴ · Pedro Oliveira⁵ · Paolo Detillo⁶ · Luca Lianas⁷ · Francesca Frexia⁷ · Pier Andrea Nicolosi⁸ · Tommaso Monti⁸ · Benedetta Bussolati⁹ · Caterina Marchiò^{2,3} · Gianni Bussolati³

Acid-Free Glyoxal



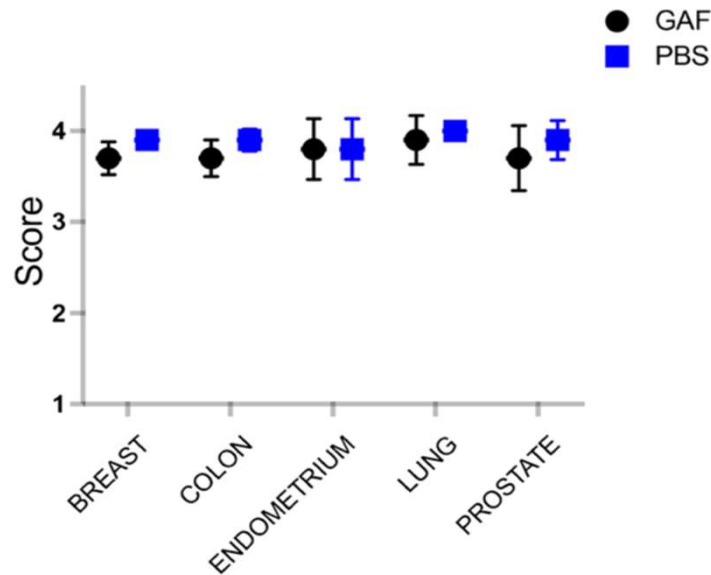


Acid-Free Glyoxal



Glyoxal acid-free (GAF) histological fixative is a suitable alternative to formalin: results from an open-label comparative non-inferiority study

Ales Ryska¹ · Anna Sapino^{2,3} · Stefania Landolfi⁴ · Irene Sansano Valero⁴ · Santiago Ramon y Cajal⁴ · Pedro Oliveira⁵ · Paolo Detillo⁶ · Luca Lianas⁷ · Francesca Frexia⁷ · Pier Andrea Nicolosi⁸ · Tommaso Monti⁸ · Benedetta Bussolati⁹ · Caterina Marchiò^{2,3} · Gianni Bussolati³

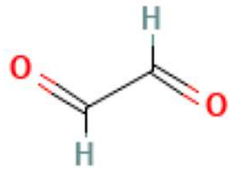


Evaluated organ	Fixative	Architectural preservation		Nuclear preservation		Cytoplasmic preservation		IHC evaluation		Overall score	
		CR	LR	CR	LR	CR	LR	CR	LR	CR	LR
Breast (n=45)	PBF	1*	0	0	0	0	0	2*	1	3.9±0.3	3.9±0.1
	GAF	7	0	0	0	0	0	7	0	3.7±0.6	4.0
Colon (n=26)	PBF	0	0	0	0	0	0	2*	0	3.9±0.3	4.0
	GAF	3	0	0	0	0	3	5	1	3.7±0.5	3.9±0.3
Endometrium (n=8)	PBF	0	0	0	0	0	0	0	0	3.9±0.3	4.0
	GAF	1	0	0	0	0	0	2	2	3.8±0.4	3.7±0.5
Lung (n=11)	NBF	0	0	0	0	0	0	0	0	4.0	4.0
	GAF	1	0	0	0	0	1	1	0	3.9±0.4	3.9±0.3
Prostate (n=10)	PBF	0	0	0	0	0	0	0	0	3.9±0.3	4.0
	GAF	3	1	0	9	0	1	2	1	3.7±0.5	2.8±0.6

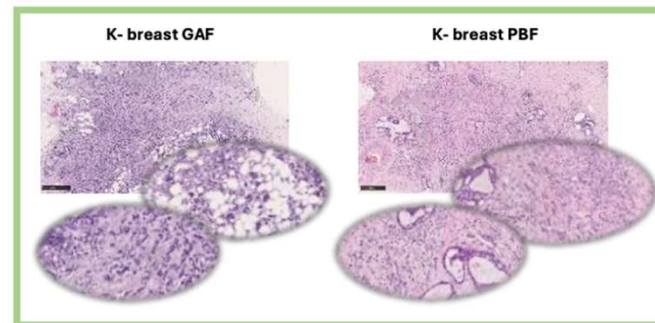
* case regarded as invalid in both fixatives

And in very long term (*i.e.* 10 years)?

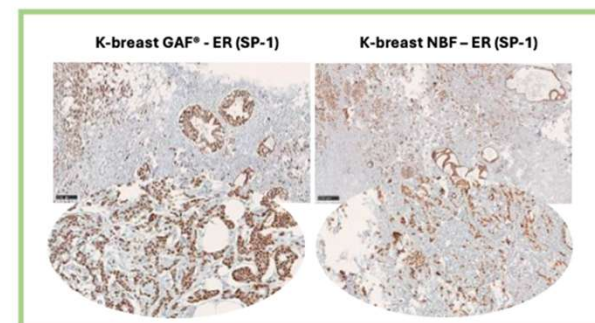
Acid-Free Glyoxal



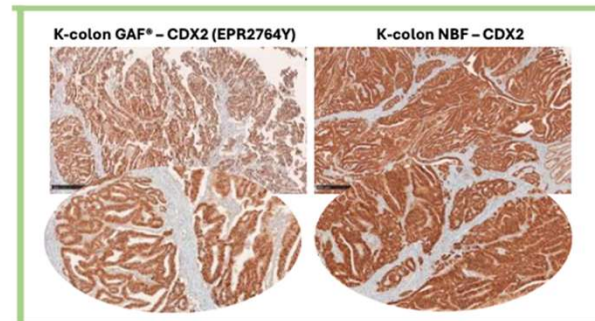
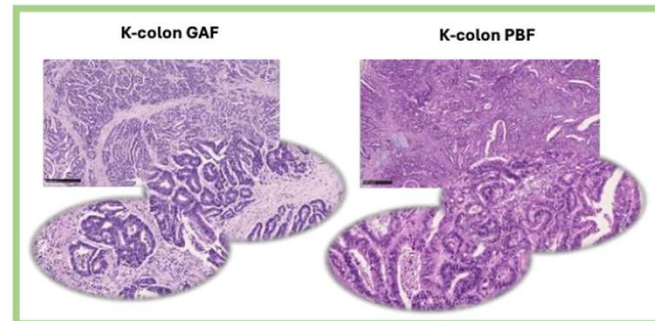
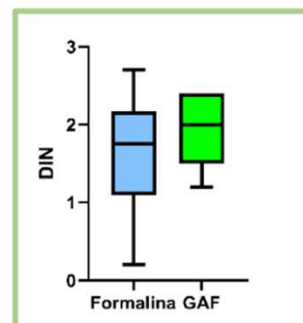
Reliable in EE



Reliable in IHC

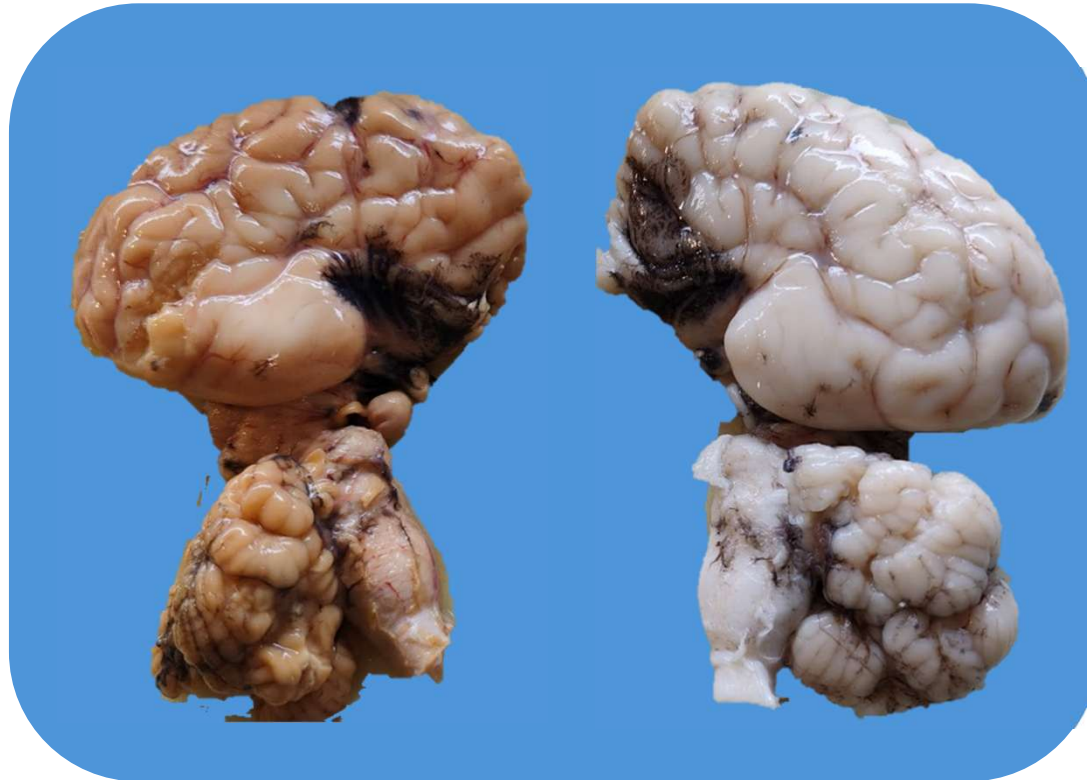
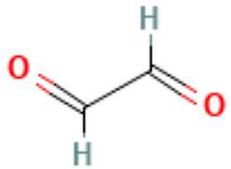


Better DNA quality



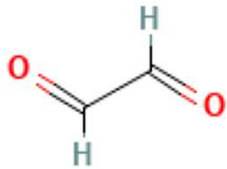
SNC

Acid-Free Glyoxal

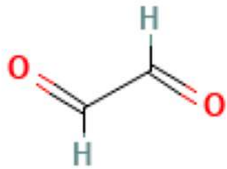


SNC

Acid-Free Glyoxal



Acid-Free Glyoxal

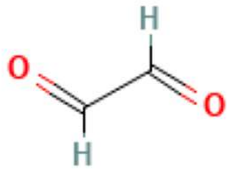


MUSCLE



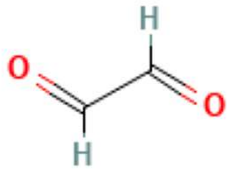


Acid-Free Glyoxal



Features	PBF	GAF®	
State of the art	Century old experience	Not inferior	
Penetration	Almost	Almost	
Fixation	Slow	Slow	
Structural preservation	Yes	Yes	
Tissue appearance after fixation	Hard	Soft	
Overfixation	Absent	Absent	
IHC	Yes	Yes	
Nucleic acid preservation	Yes	Yes, better performance in NGS analyses	
Fixative quality	Volatile	Not volatile	
Vapor toxicity	Allergenic and neurotoxic	Absent	
Carcinogenity	Cancerogenic	Not cancerogenic	

Acid-Free Glyoxal



TAKE-HOME MESSAGES

1. The Acid-free Glyoxal (GAF®) is a new generation fixative derived from the tamponade of glyoxal dialdehyde. In this way, the **critical issues described in the literature are overcome**.
2. It has a **high safety profile as it does not emit vapours and is not carcinogenic to humans**.
3. The solution has fixative power comparable to that of commonly used formalin but **has better performance in immunohistochemical and NGS analyses**.
4. **In forensic settings it facilitates macroscopic, histological and genetics analyses respecting consistency, colour and genome of tissues**.



Dipartimento di Scienze
Cardio-Toraco-Vascolari
e Sanità pubblica



UNIVERSITÀ
DEGLI STUDI
DI PADOVA



1859

Discovery of Formaldehyde
Aleksandr Butlerov



1889

Start of industrial production in Germany
and use in medicine as a fixative and
disinfectant



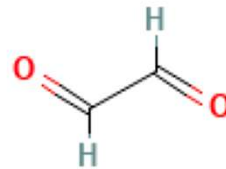


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