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AUTOMETALLOGRAPHY (AMG)

Silver enhancement of quantum dots resulting from (1) metabolism of toxic metals in animals and humans, (2) in vivo, in vitro and immersion created zinc–sulphur/zinc–selenium nanocrystals, (3) metal ions liberated from metal implants and particles

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In memory of Professor Dr. Friedrich Timm

Abstract

Autometallographic (AMG) silver enhancement is a potent histochemical tool for tracing a variety of metal containing nanocrystals, e.g. pure gold and silver nanoclusters and quantum dots of silver, mercury, bismuth or zinc, with sulphur and/or selenium.

These nanocrystals can be created in many different ways, e.g. (1) by manufacturing colloidal gold or silver particles, (2) by treating an organism in vivo with sulphide or selenide ions, (3) as the result of a metabolic decomposition of bismuth-, mercury- or silver-containing macromolecules in cell organelles, or (4) as the end product of histochemical processing of

Abbreviations: AMG, autometallography/autometallographic; CCG, cationic colloidal gold; CNS, central nervous system; DEDTC, diethyldithiocarbamate; DZ, dithizone; EELS, electron energy loss spectroscopy; ELISA, enzyme-linked immunoadsorbent assays; EM, electron microscopy; EPMA, electron probe X-ray microanalysis; GA, glutaraldehyde; GGS, gold gelatin solution; IGS, immunogold staining; ip, intraperitoneal; iZnS^{AMG}, immersion autometallographic; LM, light microscopy; MTM, membrane translocating molecules; NTS, NeoTimm solution; ntZnS^{AMG}, NeoTimm; PAP, peroxidase anti-peroxidase; PIXE, proton-induced X-ray emission; PNS, peripheral nervous system; QD, quantum dots; ZEN, zinc-enriched; ZnSe^{AMG}, in vivo selenium; ZnT, zinc transporter; AAS, atomic absorption spectrophotometry.

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tissue sections. Such nano-sized AMG nanocrystals can then be silver-amplified several times of magnitude by being exposed to an AMG developer, i.e. a normal photographic developer enriched with silver ions.

The present monograph attempts to provide a review of the autometallographic silver amplification techniques known today and their use in biology. After achieving a stronghold in histochemistry by Timm's introduction of the "silver-sulphide staining" in 1958, the AMG technique has evolved and expanded into several different areas of research, including immunocytochemistry, tracing of enzymes at LM and EM levels, blot staining, retrograde axonal tracing of zinc-enriched (ZEN) neurons, counterstaining of semithin sections, enhancement of histochemical reaction products, marking of phagocytotic cells, staining of myelin, tracing of gold ions released from gold implants, and visualization of capillaries.

General technical comments, protocols for the current AMG methods and a summary of the most significant scientific results obtained by this wide variety of AMG histochemical approaches are included in the present article.

Keywords: Autometallography (AMG); Silver; Gold; Zinc; Nanocrystals; Quantum dots; Bismuth; Mercury; Histochemistry

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Contents