

**- The metallic alloys used in dentistry, the galvanic effects...
their consequences on health –**

A talk with Jean-Marie DANZE*

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Le Monde Dentaire : Mr. Danze, you are well known in Europe for your position in the forefront of the field of electromagnetic pollution. Could you explain us from where comes your interest for health problems linked to metallic alloys in dentistry ?

J.M. Danze : Biophysics is a science which concerns the connections between the living world and physics. So, what more natural to feel interested in electrochemical processes occurring in the mouth of some persons.? More, I met many years ago, an eminent toxicologist (whose books were translated into 29 languages) : Marc Lefèvre, since deceased, who taught me toxicology. He gave me the book "Toxicity of Industrial Metals" by Ethel Browning (Ed. Butterworth, London, 1960).

Le Monde Dentaire : Could you explain us these electrochemical processes in more details ?

J.M. D. : It is easy, we all learned this during physics lessons at secondary school.

When two different metals are simultaneously immersed in a common electrolyte, it appears between these two metals an electric voltage. This one can be measured in Volt (V) or in millivolts (mV). This is the basic principle of the Leclanché battery (1877).

Le Monde Dentaire : Yes of course, but in mouth cavity ?

J.M. D. : We know that saliva is an electrolyte of very complex composition, near to this of sea water, which pH fluctuates between 6,3 and 7,3 and whose temperature oscillates around 37 ° C. When alloys or amalgams of different compositions are present in the mouth cavity, it appears sometimes electric potentials differences between two metallic pieces. These potentials differences (measured in relative values) can reach 1500 mV or even more.

Le Monde Dentaire : But how do you explain it is only from a short time, that an interest is taken about this problem ?

J.M. D. : Formerly, few importance was attached to this phenomenon, probably because one cannot imagine that it could be an origin of iatrogenic diseases, but today, the improve of knowledge in physiology and particularly in metals toxicology sets the question of prosthetic metals in the foreground of the actuality. The French newspaper of Consumers Association "*Que Choisir*", in 2002 poses clearly the problematic of dental crowns and mouth prosthesis containing nickel.

Prof. R. Soremark at Karolinska Institute in Stockholm [1] proved metal ionic migrations coming from dental prosthesis. These migrations had already be dealt with in many papers in Germany before the second world war [2]. 21 days of experiment are enough to demonstrate in indisputable manner the corroding of amalgams, of chromium-cobalt hooks and the increase of silver, quicksilver in the enamel and in the dentine of teeth filled with amalgam.

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The same problem occurs in orthopaedic surgery and a new branch of knowledge stems from this; it has for object the *biocompatibility* of metals. The biocompatible materials are materials accepted by living cells and are integrated into the structure of tissues (so are not rejected by cells) [3]. The testing of these materials can easily be performed in vitro by putting them in contact with osteoblasts (method used for implants) or with explants of gum epitheliums [4 - 5].

Le Monde Dentaire : What can be the consequence of these electro-galvanic processes for health ?

J.M. D. : The galvanic effects in the mouth cavity can give rise to two types of harmful consequences.

1. The potentials difference generated by one or more batteries voltages can by themselves disturb the neurovegetative system in the patient. We must not forget that actually, the function potential of cells membranes (neurones) is around 45 mV (Nobel prize 1991, B. Sakmann and E. Neher). Now, during sleep, the contact between the jaws is not permanent and the most of normal people show up a light friction (bruxism), which transforms then the basic direct current into impulses which can induce disturbing electric information.

When we take a sight to the branches of the maxillary nerve and to the distribution of their dendrites at each tooth root, we can understand that a triple gemelli neuralgia could have its origin in a galvanic effect (micro electric discharges) travelling from the dental filling to the nerve. Is the coagulation of the Gasser's ganglion (carried out in pain clinics) the real answer? Would it not be better before everything to look at the teeth (electrical voltages and roots overstepping) ? In other words, is it serious to destroy the alarm signal before the discovery of the intruder ?

Neurovegetative disturbances like dizziness, sleep troubles, acouphens, visual accommodation troubles a.s.o. can also rise up.

2. When two different metals give rise to a battery, the more reactive metallic element (according to the chosen convention, the more electropositive one), releases progressively ions and dissolves itself in the surrounding electrolyte. Saliva with its particular composition is an ideal medium to constitute the battery electrolyte between the fillings masses or between prosthetics parts present in the mouth cavity. It arises then simply an electro-galvanic corrosion process. The electric corrosion is not a particular phenomenon in dental practice; it constitutes a major concern for all electrochemists and for all metallurgist engineers [6]. It is a main subject by itself in a knowledge taught in universities. It is well known by plumbers, for instance, that on a water duct, when one set a brass connector on a steel pipe or on a hot-water radiator, the steel will corrode itself very quickly.

In dental practice, this case of example where an amalgam is facing or is under a gold alloy crown, this can induce an intoxication, a sub-intoxication or an allergic sensitivity following the releasing of silver, of quicksilver, of copper, of tin, of zinc, of gallium, of indium...

Now we know from some tens years ago that our cellular processes are governed by specific enzymes and searchers have identified among these enzymes, more than 600 metal-enzymes necessary for the deep metabolism of our cells. These metal-enzymes having in their structure a particular metal (for instance the ceruloplasmine, enzyme with cooper in its structure allows the fixation of iron) can be selectively blocked by a number of other metals whose atomic dimension and reactivity are close to specific enzyme metal characteristics. At all these perturbing metals take the place of the suitable metal on the molecule and play in a way the part

of a lure and blocks it. This aspect of the intoxication is hardly noticeable at the outbreak of its process and can show itself by a crowd of dissimilar symptoms and not by a particularly known syndrome.

More of this, one know also today that tiny concentrations of nickel or of cobalt or of chromium impedes repair of damaged DNA strands. This can in some cases induce a mutagenic and even carcinogenic effect [11-12-13].

Le Monde Dentaire : How could practitioners in dentistry approach these problems *in situ* with a view to solve them ?

J.M. D : As far as public health, these reasons fully justify the interest which every therapist must devote to electro-galvanic processes in the mouth cavity. During a talk I had with my friend Jean Huss, one among the initiators of the Environmental Ambulance in Great Dukedom of Luxemburg, he told me this : "*Could you imagine that a number of persons coming to consult the specialists of the Environmental Ambulance, claiming for badly definite health problems they impute to their house surrounding are healed with dental metals elimination ?* "

Le Monde Dentaire : Yes, but in practice ?

J.M. D. : The point 1 can be easily understood and brought under control thanks to the voltages differences measured with special electrodes (able to be sterilized with autoclave) fitted on a simple multimeter. One progresses with crossed measurements. The millivolt-meter gives the polarity of the dental "battery" and the more negative pole will be constituted by the alloy to eliminate. It will generally concerns a cheap metallic alloy or an amalgam.

The most the voltage differences between metallic parts are high, the most the metallic ions are dissolving in the saliva. The current intensity measurement in μA gives the quantitative expression of the process, it is to say that the metal quantity implicated in the corrosion and released as metallic ions. So the measure of a direct current in microamperes substantiates the real and continuous function of the prosthetic battery.

Some practitioners dispute this measurement method because it uses only two electrodes. Indeed, we could make use of a third electrode (considered as a reference electrode) with a view to obtain absolute values. This method would only unnecessarily complicate the measurement process, because what we are searching for is the **relative** voltage difference between two metallic pieces with a view to advise the practitioner in his work of elimination of alloys (or amalgams), these ones being **responsible** of the problem.

Le Monde Dentaire : Devices introduced on the market measure the voltage between the prosthetic metallic piece and the cheek mucous membrane. Is this measure significant ?

J.M. D. : Some therapists measure the galvanic current between the prosthetic piece and the cheek membrane mucous or between the prosthetic piece and the skin; this induces an error, because the internal resistance of the battery so measured is very high and doesn't give the real situation.

The interest of the measure must just consist in **the measurement of voltages differences between two contact points of a battery**, like we should do so to test a battery of an electric torch. It is not necessary to have overstepped the level of secondary school to understand it !

Le Monde Dentaire : Does it exist devices allowing to measure simultaneously the voltage and the galvanic current ?

J.M. D. : Devices allowing the measurement and the recording on a printer simultaneously the voltages differences in millivolts and the galvanic current in micro-amperes exist in Germany (intensity of the corrosion process pointing out the metallic released ions).

These devices are helpful and reliable, but a simple digital multimeter fitted with the appropriate electrodes can bring to the same result. It needs only some practice !

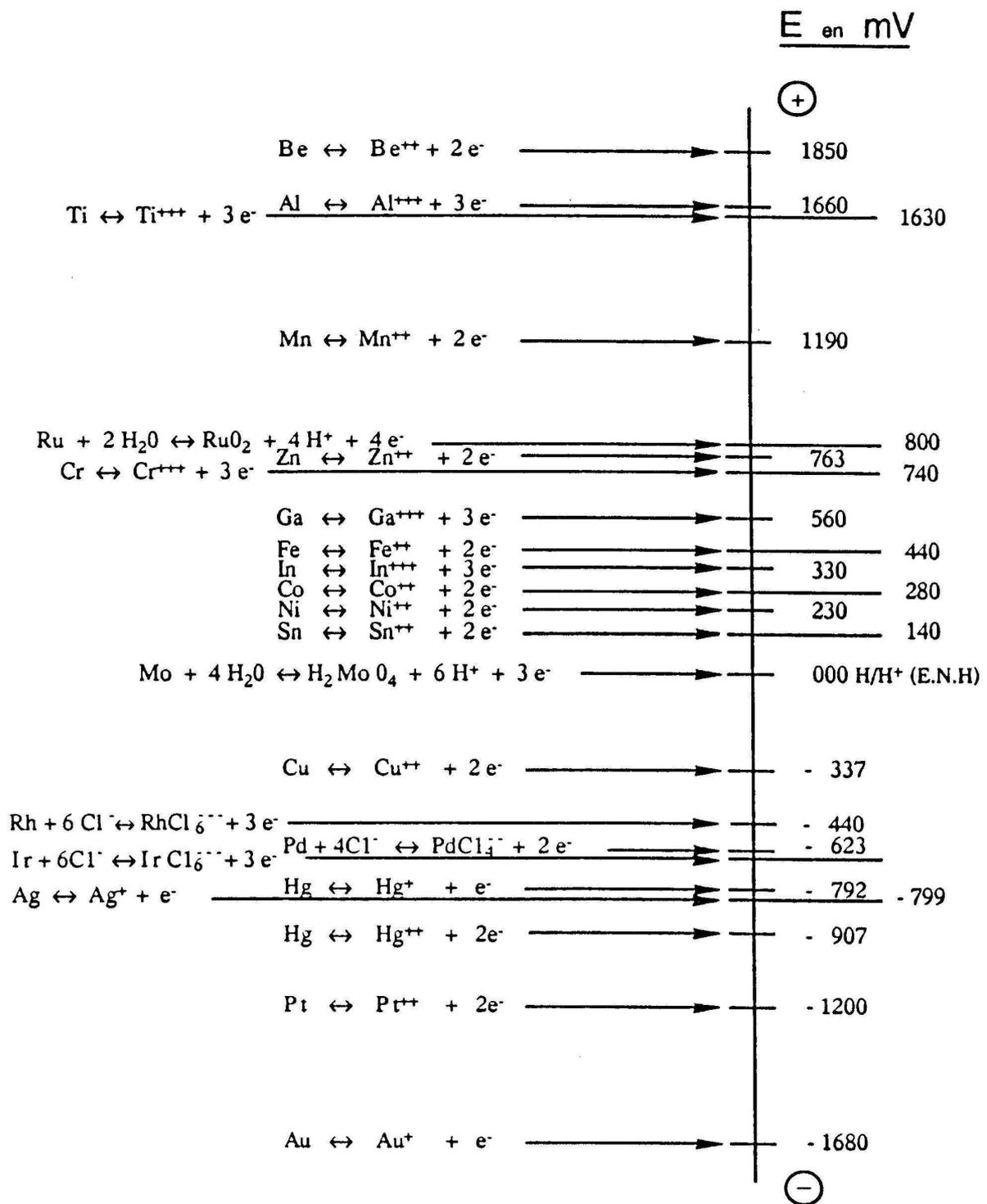
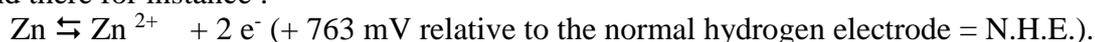


Table of reduction – oxidation (redox) potentials of metals used in dentistry (the zero value is given in reference to the normal hydrogen electrode)

Le Monde Dentaire : When one decide to place in a patient's mouth a metallic prosthesis or a particular type of tooth filling, would one take some precautions ?

J.M. D. : This concerns the point 2 here above raised. Let us see what the laws of electrochemistry say us : it exists a scale of different metals reduction – oxidation [7]. In short, each metal initiating a reaction releases one or more electron(s) and this phenomenon is accompanied with a potentials difference which can be measured in mV. The Company *Sargent* (Chicago) edited in 1963 a scale with cursors headed "*Sargent Chemical Predictor*" allowing to predict what metals are able to displace other metals by chemical ionization (analytical reaction for instance) when they would be together in the same aqueous medium.

We find there for instance :

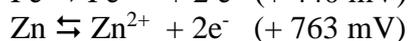
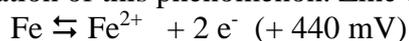


If zinc is put together with cooper in an electrolyte solution, zinc will be released in ions by the metallic cooper.



because a metal owing a negative reaction potential will displace another metal whose potential is relatively more positive.

The protection of metallic steel structures (Fe) by galvanization (Zn) is a technologic application of this phenomenon. Zinc cover protects the iron by passing into ionic solution.



$$\Delta_{\text{mV}} = 323 \text{ mV}$$

During the Second World War, in USA boat engineers let slide down along the “Liberty Ships” hulls, zinc cylinders connected to the boat hull with soldered cables. These boats were waiting in see water for their commission. Zinc was corroding itself while polarizing the steel hull leaving so the steel free from any oxidation thanks to a potential difference of 323 mV (Sea water acting as an electrolyte for the batteries so constituted).

Today the same technology is used to protect metallic steel frameworks of buildings, but thanks to the use of magnesium electrodes (whose salts are less pollutant than zinc ones). The phenomenon is the same for prosthetics alloys and amalgams in the mouth, but in this case it is the release of the most electropositive (most reactive) metal which is our concern. The direct contact between mouth metallic pieces is not necessary to give rise to this phenomenon [2], saliva conductivity is sufficient.

Le Monde Dentaire : On the table you show here, there are metals more used than other ones in dentistry. Among these ones, there are some ones which are more harmful than other ones ?

J.M. D. : We know today that 28 metals (and 2 non metals) are used in the manufacture of dental prosthetics.

The main metals, quantitatively estimated are the Beryllium (or Glucinium), the Aluminium, the Titanium, the Tantalum, the Manganese, the Ruthenium, the Chromium, the Gallium, the Germanium, the Iron, the Cobalt, the Zinc, the Nickel, the Indium, the Tin, the Molybdenum, the Cooper, the Palladium, the Zirconium, the Rhodium, the Iridium, the Quicksilver, the Platinum, the Silver and the Gold.

The table here above lets us show that we can consider as a general principle, that every metal located on a level of this scale will be released into the solution by a metal located on a lower level.

For instance, nickel present in an alloy is able to induce the releasing of iron, but gold will be able to release soluble nickel ions. Gallium is able to release soluble aluminium or beryllium. This scale is not absolute, because the pH and the chemical composition of the saliva during some moments along the days can fluctuate and change the electrode potential of one or more metals present in mouth cavity. But these fluctuations have only a low impact on the electric general behaviour of a given “mouth battery”. It is easy for everybody to measure, so to realize it. Even a 10 years old child is able to measure a mouth battery. But by the way, we must underline the case of the beryllium, located near the top of the table, it is to say releasing unavoidably itself in the saliva, when it is present together with every other metal.

How many persons have still today in their mouth beryllium alloys ? Nevertheless, the carcinogenic power of this metal, even in traces, is no more to be proven (*Encyclopédie Médico-chirurgicale Française* and *Merck Index*).

Le Monde Dentaire : But the metallurgists say that many metals can recover themselves with an oxide or hydroxide layer, this inducing a passivation against a deeper corroding process !

J.M. D. : In all corrosion processes, temporary passivation phenomenon or depolarisation can occur. These could either slow down, either activate the release of ions in the solution.

But one thing is unquestionable, the foods mastication and the bruxism constantly erode the thin oxides layer (passivation layer) and release so these substances in the digestive tract where the gastric hydrochloric acid will contribute to release the thinly divided metallic oxides into ions. We can consider that despite of the announcements of some supposedly specialists, the metal passivation in the mouth cavity does not exist considering the mechanical condition to which the metals are submitted ! The proof is that the alloys wear out in the time. What is occurring from the product of this wearing out ?

The state of the alloy area obtained by polishing or by moulding has only a short influence in slowing down the corrosion process no more than some days. Photos taken with scanning electronic microscope show this without any possible doubt [8]. On the other hand, the polishing of an alloy or of an old amalgam cleans up the area and activates again the galvanic effect.

Le Monde Dentaire : Some French Professors specialists in dentistry say that the fact of including a metal into an alloy, as for instance quicksilver in an amalgam containing tin generates a new chemical molecule where the components would lose their individual chemical properties.

J.M. D. : An important point must retain our attention : the classical metallurgy teaches us that corrosion processes are stimulated by the presence of impurities contained in the metals. And every metal plays for the whole of the alloy in which it is present, the role of an impurity. For example, a stressful problem for consumers is well known in modern iron metallurgy : the steel sheets are made from iron ore mixed with recycled iron (cars relieved from non metallic parts, destroyed before compacting in bundles and then put in the blast furnace. These bundles contain aluminium, zinc, lead, cadmium, chromium, copper, tin a.s.o.). And the cars coachworks made with these steel sheets are rusting spontaneously if they are not immediately treated against rust. This happens because of the micro-batteries constituted with metallic impurities contained in iron.

A legend is diffused among French dental surgeons, carefully entertained in high instances : *”An alloy would be a new chemical compound which would have nothing in common with the constituent metals taken individually”*. Every metallurgist chemist can clearly state, and without making any mistake, that **in an alloy, each metal holds its own starting chemical properties, even if this alloy has been perfectly melted**. More of this, no alloy is a perfect mix ! It exists in every alloy non homogeneous micro-zones where at least, one of the components forms little crystalline structures of pure metal. Each metal present in the alloy

forms such heterogeneous micro-zones. These zones are clearly visible with the help of a scanning electronic microscope. From the surface, micro-batteries will appear and give rise to corrosion which will become the origin of metallic ions release. The quantities of these ions will not be very important, but they will be sufficient to generate sensitiveness of allergenic types in sensitive subjects (the simple contact of nickel or cobalt with skin or with mucous membranes, without any corrosion process, can give rise to allergic symptoms).

Le Monde Dentaire : And now, if we approach the so controversial case of amalgams ?

J.M. D : Amalgams are as it were alloys composed at room temperature. So, quicksilver, which at this temperature is in a liquid state (it constitutes 51 % in weight in the amalgam), is mixed with a powder containing silver, copper, tin, zinc, and quicksilver. The powder particles are atoms aggregates and it goes without saying that their dispersion in liquid quicksilver will let remain a number of these aggregates. There will not be any total solubilisation of metals in quicksilver. Examined with scanning electronic microscope an amalgam section shows the aggregates well distinguished from the peripheral quicksilver alloy (more homogenous). Each grain so differentiated will give rise to a micro-battery in the saliva with the surrounding quicksilver, with solubilisation of the more electropositive metals, it is to say silver, zinc, tin or copper. The corrosion will slowly progress in depth... If in the mouth cavity, a crown in gold alloy is placed, a new battery will appear, but this time between quicksilver and gold and quicksilver will be released as Hg^{2+} ions. Micro-excavations will appear and form little channels which will extend themselves to the whole filling.

The quicksilver corrosion phenomenon in amalgams fillings was already known by amalgams producers in Germany from 1960 as it has been clearly demonstrated by experts' valuation in 1995 at the Toxicology Institute at University of Kiel [2]. It is so unthinkable that this knowledge would not leak in other European countries.

More of this, a study carried on at Tübingen University (Germany) on 17000 patients, published in 1996 [9] showed that amalgam fillings release important quantities of quicksilver vapours in the mouth cavity. Some patients are so exposed to more than 200 times the accepted standard in Germany for professional exposures, in terms of acceptable dosis.

Le Monde Dentaire : We can often read that foods and mainly fishes constitute a factor of important supply of quicksilver in our tissues.

J.M. D. : The World Health Organization claiming that the maximal absorption of quicksilver regarding public in general could come from fish eating (and repeated all together by public health authorities) is simply made ridiculous in the toxicology expert valuation of Kiel University. It would perhaps be judicious to ask oneself if the W.H.O. experts have well as aim the health protection. In any case, if this is the W.H.O. experts position, we should ask ourselves about the reasons of such a rigour lack from personalities who would be above suspicious.

Le Monde Dentaire : But, how can we explain that following such an expert valuation made by the Department of Toxicology at Kiel University the public authorities don't forcefully legislate ?

J.M. D. : We can say that generally some persons in charge of Public Health prove a great lightness. This already appears in the Kiel University report (without mentioning the numerous influences exerted by German administration to hush up this matter).

With regard to this, I think that like about a lot of public health matters, this attitude is intended to ensure an economic seeing within a short time. The costs of the solution is not estimated in social safety economy which could induce a decrease of iatrogenic diseases connected to some dental metals, but in immediate costs of amalgams replacement with other materials.

Le Monde Dentaire : Nevertheless, the quicksilver toxicity for nature is recognized ! Its use is forbidden in woods treatments because of its perennality . The problem of amalgam dental fillings is clearly settled about human incinerators quicksilver vapour residues.

J.M. D. : Quicksilver contained in a supple unbreakable polyethylene flask (to avoid the spilling of this metal volatile at room temperature), marked with a label putting on guard against every handling danger becomes harmless in a dental filling ! The miracle will appear ...in the dentist's practice. The paradox becomes so evident that the dental millings wastes in dental practices give rise to problems for the environment.

Then, official authorities contort themselves on trying to prove that a non-gamma-2 amalgam does not release any quicksilver; that quicksilver would be completely fixed into a new chemical compound with tin, perfectly stable. The Toxicology Institute of Kiel [2] showed that in Germany, from more than 20 years, universities searchers proved that **all** dental amalgams release quicksilver vapours and even in some cases, tiny quicksilver drops from surface. The results of these researches were hushed up on the level of dentistry practitioners ! Why ? Does Science have not the same meaning when it implies great industrial lobbies ?

Le Monde Dentaire : But one repeat that one find only very rarely quicksilver in blood or in urine from amalgams bearers !

J.M. D. : Yes, some toxicologists try to let us show that quicksilver intoxication following the presence of amalgams does not exist because the quicksilver doses found in blood and in urine are practically the same for all persons, even for these ones who are not bearing amalgams. They of course lose sight of the fact that blood and urine are only transition sites for quicksilver either on the form of vapour, either on the form of salts, either on the form of methyl-quicksilver. For instance, one could observe an important increase of blood and urinary quicksilver on the day following the milling of an amalgam without any precaution [9]. Let us remind that in toxicology, there are target organs and that a metallic intoxication will sometimes consist in a slow increase of metal traces on the level of these organs. It needed a lot of years (and how many deaths from cancers) to understand that the DDT is preferentially stocking itself in fatty and conjunctive tissues. The toxicology of quicksilver points out that quicksilver target organs are the brain, the kidneys and the liver [10]. A recent study carried on workers in Philippines gold mines [14] (gold is purified by amalgamation) shows that these workers very deeply intoxicated by quicksilver present all symptoms of chronic intoxication (hydrargyrisms), but do not reveal any pathologic concentration of quicksilver in their blood nor in their urine whereas other workers at first sight less affected in fact of observed symptoms show very high levels of quicksilver in their blood and in their urine. Prof. G. Drasch and his team of Munich searchers who carried on these studies during one year conclude that the dosages variations are too important to allow the use of blood and urine analyse as follow up parameters in quicksilver intoxication !

The German studies of Tübingen [9] and Kiel [2] had already showed that among the population a great number of persons are suffering from health troubles induced by amalgams fillings. Sometimes these troubles are heavy, sometimes they are reduced to a bad feeling which does not incite to consult a physician. But is it necessary to repeat it : these patients suffering from headaches, from neuralgias, from dizziness, from insomnias from shakings consume continuously drugs (which will add a new iatrogenic effect) and costs assumed by the collectivity because of the productive capacity decrease ?

Le Monde Dentaire : You understand that the blur is kept with a view to present us false information under the sight of indisputable truths ?

J.M. D. : I only verify facts. The historical problems like the contaminated blood, the asbestos, the bovine spongiform encephalitis, the growth hormones showed us of indisputable manner that the persons who have to officially decide, elected by the population let economic concerns be preponderant over public health problems. These scandals were only brought in

light thanks to some independent journalists accomplishing really their job to inform us. Other health problems will impose on us about mobile phones and transmitters in the following months. The elected politicians continue to follow pressure exerted on them by the industry leaders so denying the Precaution Principle as it was formulated and approved by the same politicians at Rio Conference. All these sorrowful adventures lived by many families and individual persons victims of them had nevertheless let reflect the experts who advise the politicians... unless the decision makers would no more be the politicians !

This behaviour shows us that citizens health has only a weight during the political speeches of electoral campaign, but that in reality it is often kept off regarding to enormous financial interests hid under collective interest mask.

Le Monde Dentaire : What concrete solutions can we propose ?

J.M. D. : It is clear that metallic dental alloys and the amalgams pose a number of problems

1. On our opinion it is urgent to find a replacement solution of the amalgams. It would really be paradoxical that on our era where we are able to send rockets designed for the study of Moon, Jupiter, Mars soils that we could not find a material substitutive to the amalgams.
2. As to the other metals a number of experimental data must be taken in account:
The Beryllium is without any doubt one of the more toxic metals and his redox potential informs us that it is the more sensitive metal to electro-galvanic effects (releasing into ions). It is particularly dangerous as his density is very low (1.84). So a little percent of weight of Beryllium in an alloy does not reflect the corrosion area it present in an alloy (much higher than its weight part).
In our opinion this metal would be immediately banned from dentistry and alloys present in patient mouth immediately eliminated.
3. **The sensitivity of a patient to an alloy or to an amalgam is not a statistical question : it is individual !** There also, approach methods exist and if you allow it we can further come back to them.

References :

- [1] Soremark R. Et al., "*Influence of some dental restorations on the concentrations of inorganic constituents of the teeth*", Dep. Prosth. and Clinical Lab. of Royal Sci. Dent., 1962.
- [2] Wassermann et al. « *Kieler Amalgam-Gutach* » (*Expert work carried on by the Institute of Toxicologie at Kiel University on request of public prosecutor at Court of Francfort/Main*), 1997.(translated into French language in the book : *Amalgames dentaires, une question de Santé Publique*, Ed. Pietteur Liège - Belgium).
- [3] Harmond M.F. (INSERM S.C. 31) et al. « *Odontologie, Stomatologie, expérimentation in vitro de la bicompatibilité et du comportement des métaux* », Enjeux, n°74, nov. 1986.
- [4] Sigot-Luizard M.F. (CNRS) « *Evaluation in vitro de la cytotoxicité et de la cytocompatibilité d'alliages dentaires précieux et non précieux sur culture organotypique de gencive humaine* »
- [5] Wataha J.C., Malcolm C.T., Hanks C.T." *Correlation between cytotoxicity and the elements released by dental casting alloys*", Int. J. Prosthodont 8: 9-14 (1995).
- [6] Philibert P., « *Protection contre la corrosion* » p.12-15, Ed. Presses Universitaires de France, 1973
- [7] Danze J.M. « *Le Système Mora ou le Rationnel en Médecine Energétique* », Ed. Pietteur-Liège Belgium 4th Edition in French language (mis à jour et réédité).
- [8] Hildebrand H.F. and Champy F., "*Biocompatibility of Co-Cr-Ni Alloys*", Ed. Plenum Press, New York, 1988.
- [9] Roller E., Weiss H.D., Maier K.H. « *Etude de l'Université de Tübingen concernant les Amalgames dentaires* » (2 parts), Institut of Environment Analyse and Institute of

Gynecologia, Univ. Tübingen 1996 (translation into French language in the book : *Amalgames dentaires, une question de Santé Publique*, Ed. Pietteur Liège - Belgium).

[10] Testud F. « *Pathologie toxique en milieu de travail* », Ed. Lacassagne Lyon, 1993, pp.142-146.

[11] Hartwig A., Mullenders L.H.F., Schlepegrell R., Krueger I, Beyersmann D. “*Interaction of nickel (II) with D.N.A. repair processes : inhibition of the incision step in nucleotide excision repair*“, Metal Ions in Biology and Medicine, Paris (1994) pp.235-240.

[12] Rodilla V., Miles A.T., Hawksworth G.M., “*Metal toxicity and induction of metallothionein in cultured human proximal tubular cells*”, in Metal ions in Biology and Medicine, Vol.4, Paris (1996) pp. 88-90.

[13] Littlefield N.A., Hass B.S., “*Effect of magnesium on DNA damage from cadmium, nickel, mercury and lead*”, in Metal ions in Biology and Medicine, (1994) Paris, pp. 507-512.

[14] Drasch G., Institut für Rechtsmedizin, München, “*Die Werte streuen viel zu stark*” Zeitschrift für Umweltmedizin, Heft 4, p.204 (2001).



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