AN INVESTIGATION INTO THE CAUSE AND PREVENTION OF INDUSTRIAL DISEASES DUE TO TETRYL.

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In November, 1915, on account of the prevalence of industrial dermatitis among the workers in tetryl in certain works, I was asked to advise as to the prevention and cure of this complaint, which was seriously interfering with the health of the workers, and causing difficulty in employment.

Tetryl had, previous to the war, been used without special precautions and with little ill-effect, but at that time the compound was mixed with a certain percentage of gum, so that no dust rose when it was being manipulated. As now used tetryl is a yellow powder, which readily rises in the work-room as dust, and consequently charges the atmosphere, and covers with its particles both the workers and the work-room. Coincident to this change, dermatitis, etc., in the workers developed. Examined under the microscope tetryl is seen to be composed of finely divided crystals liable to fracture, the broken ends being sharp. Compared to T.N.T. and picric acid the crystals are smaller, have less tendency to agglutinate in masses, and their edges are sharper. Hence tetryl, of the three, is a greater mechanical irritant.

The comparative solubility in water expressed as per cent. by weight is as under :

Temp. . . .	13° C. . .	100° C.
Picric acid . .	1·114 . .	4·80
T.N.T. . . .	0·003 . .	0·063
Tetryl . . .	0·003 . .	0·069

It will thus be seen that though all three produce yellow staining of the skin in different shades, picric acid crystals are large and tend to agglutinate and have rounded edges; the crystals of tetryl are smaller, have sharp edges, and tend to agglutinate only slightly; and that T.N.T. occupies a midway position between the two, except in the fact that its insolubility is the same as tetryl.

The Causes of Dermatitis in Tetryl Workers.

Presumably there are two—mechanical and chemical.

Mechanical.—The nature of the crystals suggests that they are potent mechanical irritants to the skin.

Chemical.—This point so far as I know is not settled, and requires investigation. It is probably not an oxidisation similar to that of, say, chromic acid dermatitis. Tetryl is a fairly stable compound, but it is quite likely that a compound containing so many "nitro groups" (NO_2) would at an ordinary temperature react as an oxidiser if brought into contact with suitable reducing agents. This oxidising action may be dependent on the conversion of the nitro groups into an amino (NH_2), just as nitrobenzine ($C_6H_5NO_2$) is converted into aniline ($C_6H_5NH_2$), a reaction which may be represented thus:

$$C_6H_5NO_2 + 3H_2 = C_6H_5NH_2 + 2H_2O.$$

Here the nitrobenzine, which is soluble in the cholesterin fats of the skin, acts as an oxidiser. Nitrobenzine itself is not a ready oxidising agent, but where, as in tetryl, there is an accumulation of tetro groups, will readily act as an oxidiser, and in doing so one or more of the NO_2 groups are converted into amino groups, and compounds nearly related to aniline would result. Thus from tetryl acting as an oxidiser such a derivative as $C_6H(NO_2)_3NH_2NHCH_3$, *i. e.* amino-trinitro-methyl-aniline, might be obtained. An action such as this is in no way related to the violent action which would result from the combustion, *i. e.* the oxidation, of tetryl, much less like the change which results when it explodes. It is thus possible that tetryl may act on the skin in some specific way not yet determined, and it may or may not be associated with an oxidising agent.

The Symptoms of Tetryl Poisoning.

The symptoms produced in persons working in tetryl present a fairly uniform type, viz. an inflammation of the skin which is exposed to tetryl dust, irritation of the nasal mucous membrane, the pharynx, and to some extent the stomach, etc. Only once have I seen constitutional symptoms, and they were transitory.

Dermatitis.—This is by far the commonest complaint. Without precautions 32 per cent. of the workers were affected with it, many of them severely. The location of the dermatitis corresponds to the skin

area not protected by clothing during work, viz. the hands and forearms, the face, neck and upper part of the chest, but in a few cases the skin was inflamed down to the iliac crests if the clothing was loose and scanty about the shoulders. Subjoined is a typical early case before any precautions were taken.

A. W., aged 39 years, worked for eleven days weighing out tetryl powder to be compressed into pellets. She has marked dermatitis of the hands and forearms, and face, which is red, swollen, eyelids œdematous, and there is a purulent discharge from a well-marked conjunctivitis; the back of her neck is similarly red and swollen, especially behind the ears, and this applies also to the front of her chest following a V-shaped area on the front where her blouse has been turned open. The acute stage lasted several weeks and was followed by extensive peeling and much itching. There are no constitutional symptoms, her whole complaint being her skin. Her appetite was increased after starting this work. There was no epistaxis.

Cases like the above were very common, but as precautions were taken the degree and severity became less and less. Thus it happened later that only an occasional very susceptible person had anything like the severity of the above case, and what in the end occurred was a little dermatitis about the chin or the back of the neck, amenable to treatment and not necessitating removal from the work in hand.

Dermatitis occurs in two varieties: (1) as a rose-red inflammation affecting the skin uniformly, and (2) as a papular rash apt to discharge sero-pus if allowed to remain untreated. As a rule both varieties are preceded by itching, sometimes intolerable.

Epistaxis.—Nearly all workers suffer from sneezing, and slight epistaxis is not uncommon.

Pharyngeal irritation is occasionally complained of, but I have no notes of any marked tonsil inflammation.

Stomach symptoms.—Vomiting of bile and stomach contents was not infrequently reported, and in a small percentage of cases was due to swallowing tetryl powder, but it was often very difficult to separate genuine cases from sickness due to other causes (*e. g.* menstruation), and the popular idea among workers that the yellowness of the vomit was due to tetryl and not bile had to be excluded.

Increase of sexual appetite was in the early stages reported as a symptom, but careful investigation failed to confirm this. Only 2 per cent. of the married women questioned confirmed this.

Constitutional symptoms.—These in my experience are very rare,

and I have seen only one case, viz. that of a foreman who had been in contact with tetryl every day for several months, and was seen before this investigation began. His skin was deeply stained yellow, there was dermatitis of the face with œdema of the eyelids, vomiting and abdominal pain, and very distinct pain in the legs following the course of the sciatic nerve and its branches, and this was regarded as a slight neuritis. He also had breathlessness, and slight, though quite evident, lividity of the lips, the exact shade masked by the yellow staining. He recovered completely in a fortnight. His blood was examined, and the only change found was slight variation in the size of the red blood-corpuscles.

Careful examination of blood-films before commencing work and after showed the following. The method employed was to examine all the workers before commencing a fortnight's shift, take two blood-films from each, and repeat the process at the end of the shift. The table (pp. 22–23) shows the result.

It will thus be seen that no characteristic changes in the blood were detected. In three cases the comparative size of the red blood corpuscles were noted as altered, but there were no nucleated cells, and this is the only noteworthy alteration. It is to be noted that all these blood films were examined when the fourteen days' shift existed, and when fairly marked cases of dermatitis and gastric irritation were occurring.

Treatment.—Tetryl dermatitis requires no different treatment to dermatitis occurring from other causes. The inflamed surfaces should be carefully washed with warm olive oil to remove discharges, and should then be coated with a lotion containing:

Calaminæ	gr. 20
Pulv. zinc ox.	gr. 15
Aq. calcis	℥ ij
Aq.	℥ ij
Ol. olivæ	ad ℥ j

and covered with sterile butter muslin, or well smeared with ung. zinci oleat., each application being washed off with warm olive oil and cotton wool before a fresh dressing is put on.

If this is carefully done in the early stages, many cases will subside at once. The more severe cases may take several weeks to recover, and some that are neglected and become septic have required

Cases.	Before working in tetryl rooms.				After working 14 days in tetryl rooms.			
	Reds.	Polymorphs.	Hyaline.	Remarks.	Reds.	Polymorphs.	Hyaline.	Remarks.
1	Normal.	Normal.	Slight increase.	—	Slight variation in size.	Normal.	As before.	Slight dermatitis of face for one day.
2	,,	,,	Normal.	—	Normal.	,,	Normal.	Very slight dermatitis of chin.
3	,,	,,	Slight increase.	—	,,	,,	As before.	No symptoms. Increased appetite.
4	,,	,,	Normal.	Was anæmic six months ago.	,,	,,	Normal.	Very slight dermatitis of chin. Increased appetite.
5	,,	,,	,,		,,	,,	,,	No symptoms. Increased appetite.
6	,,	Slight increase.	,,	Eosinophiles present. Dyspeptic girl.	,,	Increase.	,,	No eosinophiles in these films. No dermatitis.
7	,,	Normal.	,,	Acne face.	,,	Normal.	,,	No symptoms.
8	,,	,,	,,	Acne forehead.	,,	,,	,,	Slight dermatitis where acne existed.
9	,,	,,	,,	—	,,	,,	,,	No symptoms except sneezing and epistaxis once.
10	,,	,,	,,	Acne forehead.	,,	,,	,,	No symptoms.
11	,,	,,	,,	Very dark complexion.	,,	,,	,,	Dermatitis face with œdema of eyelids.
12	,,	,,	,,	Acne chin.	,,	,,	,,	No symptoms.
13	,,	,,	,,	Slight scaly eczema forehead.	,,	,,	,,	No symptoms.
14	,,	,,	,,	Slight acne forehead and chest.	,,	,,	,,	No symptoms.
15	,,	,,	,,	Gets profuse vasomotor sweating of face.	,,	,,	,,	Dermatitis face and œdema of eyelids after 10 days' work.
16	,,	,,	,,	—	,,	—.	—	Absent, but no symptoms.
17	,,	,,	,,	Clean, very dark complexion.	Slight variation in size. None nucleated.	Slight increase.	Normal.	Bad dermatitis face. Susceptible person.
18	,,	,,	,,	Very fair complexion.	Normal.	Normal.	,,	No symptoms.
19	,,	,,	,,	—	—	—	—	No second film.
20	,,	Increase.	Increase.	Very dark complexion. Worked in fields all her life.	Normal.	No increase.	No increase.	Bad dermatitis face. Susceptible person.

Cases.	Before working in tetryl rooms. Reds.	Polymorphs.	Hyaline.	Remarks.	After working 14 days in tetryl rooms. Reds.	Polymorphs.	Hyaline.	Remarks.
21	Normal.	Normal.	Normal.	Very fair complexion.	Normal.	Normal.	Normal.	Dermatitis face and neck.
22	,,	,,	,,	Acne chin. Sweats readily.	,,	,,	,,	No symptoms.
23	,,	,,	,,	—	,,	,,	,,	Very slight dermatitis chin.
24	,,	,,	,,	Dark complexion.	,,	,,	,,	Papular dermatitis neck.
25	,,	,,	,,	Very dark complexion.	,,	,,	Increase.	Dermatitis face and œdema eyelids.
26	,,	,,	,,	Very dark complexion.	,,	Increase	Normal.	Very slight dermatitis face.
27	,,	Increase.	,,	Very dark complexion.	,,	Normal.	,,	Dermatitis face and vomiting.
28	,,	Normal.	,,	Dark complexion.	,,	,,	,,	Papular dermatitis chin and cheeks.
29	,,	,,	,,	Very dark complexion.	,,	,,	,,	Slight dermatitis hands.
30	,,	,,	,,	Fair complexion.	,,	,,	,,	Dermatitis face and œdema eyelids.
31	,,	,,	,,	Dark complexion.	,,	,,	,,	Dermatitis face, nose bleeding and sickness.
32	,,	,,	,,	Fair complexion.	,,	,,	,,	Slight dermatitis face, nose bleeding. Increased appetite.
33	,,	,,	,,	Very dark complexion.	,,	,,	,,	No symptoms.
34	,,	,,	Slight increase.	Very dark complexion.	,,	,,	No change.	Patchy dermatitis face. Epistaxis. Increased appetite.
35	,,	,,	Normal.	Fair complexion.	,,	,,	Normal.	No symptoms.
36	,,	,,	,,	Fair complexion. Red auburn hair. Delicate skin.	,,	,,	,,	Very susceptible girl, got acute dermatitis of face in a few days with marked itching, and this was still marked when blood film was taken. She also had sickness and much vomiting.
37	Foreman with constitutional symptoms mentioned above. Blood film taken after recovery.				Variation in size of red corpuscles. None nucleated.	,,	,,	—

months to recover. These, however, are the exception, and have been due to neglect on the patient's part.

Prevention of Dermatitis, etc., in Tetryl Workers.

In the framing and instituting of means to prevent tetryl dermatitis several principles have to be considered:

(1) Dermatitis is the chief disease among tetryl workers.

(2) Dermatitis occurs on that part of the body exposed to tetryl dust of the workrooms.

(3) The amount of dust is in direct ratio to the occurrence of skin inflammation.

(4) The resistance of the skin is in direct ratio to the length of exposure to the irritating dust.

(5) No means has yet been discovered to neutralise the irritating effect of tetryl on the skin and mucous membranes of the respiratory and digestive tract.

(6) Tetryl is practically insoluble in water, but more soluble on greasy skins.

It therefore follows that the means of prevention are to be found, in the present state of our knowledge, in the protection of the skin from irritating dust and the purifying of the air of the workrooms, so that as little dust as possible is inspired or swallowed. On these principles means were gradually evolved, and the finished product is as follows:

The workrooms.—These should be lofty and well ventilated, but not draughty. There should be no ledges on which dust can settle; thus the walls should be smooth, and if made of wood they should be well varnished. The window-frames on the inner side should be nearly as possible flush with the glass, and any overhead beams should be latted on the top with a triangle apex upwards. As few partitions as possible should exist on the work tables—it is a mistake to provide a partitioned space for each worker. The tables should be smooth, and, indeed, the whole construction of the room so arranged that as little dust as possible accumulates, and if and where it accumulates it can be easily removed.

Perhaps the most important factor in the prevention of dust in the workrooms is the efficient working of exhaust fans. The method employed at —— is as follows:

A table is arranged round the wall. The top of the table at distances suitable for each worker at the table has a perforated grating or wire grid, each leading down to a suction duct, which communicates with a common duct that passes through the outside wall of the room under the table, where a suction fan is fixed. Interposed between the end of the common duct and the suction fan a chamber or filter of wet coke should be interposed to prevent the tetryl dust getting into the bearings and possibly exploding. This arrangement catches the dust, and coke should be changed from time to time. This arrangement of bench occupied the end and part of the sides of the room. It is advisable that one fan should not be relied on to produce an in-suction draught to too many gratings, as those farthest from the fan are apt to have feeble in-suction power.

At the farther end of the room there is an ordinary table, at which workers gauging the pellets sit.

Clothing.—Each worker wears a long khaki jacket or overall, made non-inflammable, and the sleeves so arranged that they button round the wrist, and the neck should be high and fit closely. It is possible that a material with a more glossy surface than khaki would be an improvement.

Each worker should wear soft wash-leather gloves, which fit well and reach up to the elbows. These should be well cared for, discarded when they get hard, and should never have holes in them.

Veils.—These have always been a trouble, because the women disliked wearing them, and a mesh small enough to prevent the passage of dust obstructed clear vision. They were ultimately discarded, as it was found that perfect powdering of the face and neck was more agreeable and equally efficient. If veils are worn they should be supported on a light framework or light broad-brimmed hat, so as to remove them well from the face, and they should be ample and long enough to come below the shoulders, both before and behind.

Face powder.—Nothing is better than two parts of zinc oxide to one of starch. It should be stored in an ante-room, or in a cupboard used only for this purpose in the workroom, so as to be certain no tetryl dust gets into it. It should be applied very thickly to the face and neck. Powders are to be preferred to oily preparations.

Washing arrangements.—These should be ample, and the best consists of a long porcelain trough with a constant inflow of hot and cold water at one end, and a waste pipe at the other, slightly above the level of the bottom of the trough.

Cloak-room.—A separate cloak-room should be provided for the storing of tetryl gowns, or a special department in the general cloak-room, in which no one but tetryl workers are allowed.

Length of shift.—In the earlier stages each person worked for fourteen days in the tetryl rooms. It was soon discovered that more trouble occurred in the second week. The shift was therefore limited to seven days, and this was found to be a great improvement. The limitation of output was soon got over because in a few weeks the old trained workers returned.

Routine of daily work.—When the women arrive in the morning they should be given a glass of milk or cocoa. They then proceed to the cloak-room to get their gowns and gloves. Arrived at the work-room they powder their faces and necks thickly with the face-powder, returning it to the special cupboard provided for the purpose. Those thus properly clothed and powdered proceed to the gauging table and no other directions are needed. Those who are to work with loose tetryl take their places at the table beside the in-suction wire grids, place the mull containing the loose tetryl on the grid, and also the small weighing scales. It thus follows that as they lift the tetryl on to the weighing scales the fine dust is sucked into the grid and does not disseminate in the air.

When a meal interval arrives each individual takes off her gloves, hangs them on a clothes line outside, proceeds to the washing room and washes her hands, face and neck. Resuming work she repowders herself, puts on her gloves, over which she buttons her tunic at the wrist, and proceeds as before, the routine being repeated at each meal interval.

Stringent directions are given that no loose tetryl is allowed to remain on tables or floor, and if any is found damp cloths are provided to remove it. The workrooms should be frequently washed out.

Considerable supervision is required, as many workers are extremely careless, and regard regulations as tasks, rather than for their benefit.

The gowns should be washed at least once a week, and gloves more frequently. If veils are used they also should be washed frequently, and, like gloves, hung in the open air. To avoid gastro-intestinal irritation every worker was given a dose of magnesia or mist. alb. every other day.

One or two practical points remain :

(1) Weekly inspection of workers before going to work, with the object of trying to discover who were susceptible and who were not, was found practically useless. The complexion, dark or fair, the presence of acne was for weeks noted, but no working rule could be discovered. (*Vide* remarks in blood-examination table ; many more than these were tabulated.)

(2) A very small percentage of people are very susceptible, and these resist all precautions. They should be permanently sent to other work.

The following is a typical case on December 6th, 1915 :

A man worked in tetryl room for one day, the next he had intense itching of the face followed by acute dermatitis, with œdema of the eyelids. In ten days he had apparently recovered, went back to work, and at once relapsed. In about the same time he had again apparently recovered. He put on one evening the suit of clothes he wore in the tetryl room when he at once relapsed.

(3) If a dermatitis is treated early, it is usually checked and work can continue.

(4) After workers have completed their shift they should be told that if there is the slightest sign of skin irritation, they should report it at once. During the course of the investigation a considerable number of cases left the workrooms quite free, and weeks afterwards sent in a claim for compensation, and it was discovered that the dermatitis, at first slight, by neglect became septic and very marked.

(5) It is of some importance to exclude all non-tetryl workers from their cloak-room. Two of the worst cases of dermatitis seen were due to women, not working with tetryl, covering their heads with tetryl gowns in the cloak-room during a thunderstorm, and another was the washerwoman in the cloak-room.

(6) If an apparently recovered case of dermatitis is put to work in a very warm room, such as a lacquering room, the dermatitis is apt to relapse.

In the gradual evolution of precautions it was interesting to note :

(1) The wearing of long wash-leather gloves practically at once abolished dermatitis of the hands and forearms. For months before tetryl ceased to be worked at —— no case was reported on the hands or forearms.

(2) The efficient ventilation and construction of the new rooms had a distinctly beneficial effect.

(3) When the fans became efficient the atmosphere was strikingly less dust-laden, and soon diminished the number of cases. There were two rooms, N and W ; in N the fan was efficient ; in W there was delay and difficulty in procuring a fan, during which time more cases occurred in W than N.

(4) Thicker powdering was an efficient substitute for veils.

(5) The immediate removal of all loose powder in the room was helpful.

Results.—Available statistics when the investigation began, in December, 1915, and before any precautions were taken, show 34 per cent. of workers affected in one way or another.

When in February, 1916, new premises, gloves, face powder, veils, but no fans or seven-day shifts, had been instituted, my notes indicate the absence of dermatitis of the hands and arms, and though several cases of dermatitis of the face were reported at each fortnightly inspection the severity was less marked.

There were two workrooms, N and W.

In room N all precautions were taken and the fan arrangement was efficient.

In room W all precautions were taken, but the fan arrangement was not efficient.

Weekly shifts were commenced on April 5th, 1916, and from this period to November 21st, 1916, when work on tetryl was stopped :

6 cases had to leave before their 7 days were completed because of face dermatitis (chiefly) .	in room N.
18 cases had to leave before 7 days were completed because of face dermatitis (chiefly) . . .	in room W.

As a rule twenty-four women were employed each week in each room—day and night shift—giving a grand total of approximately 1430. Of slight cases treated at once by the resident nurse at the

ambulance station and checked, there were, in addition to the above:

30 in room N.
39 in room W.

It is noteworthy that the number of these was diminishing month by month as the smaller details were being more carefully carried out.

The compensation figures require some explanation.

In July, 1916, my attention was directed to the size of the compensation account. It was a revelation to me, as the number of cases was steadily diminishing in the tetryl rooms with the precautions observed. I ordered that everyone on compensation should be presented to me weekly for examination. The result proved a revelation of how compensation can be claimed and paid on grounds apparently real, but on fallacious expert examination.

I found many of the cases in the women workers genuine enough in origin, but prolonged from sheer neglect on the part of the individual. Efficient treatment cured these cases, and they disappeared from the compensation list. One case in particular is noteworthy. A young woman had in April genuine tetryl dermatitis; she continued on the compensation list for a long time with a skin eruption. Investigation proved this rash to be due to syphilis; needless to say, she was soon off the list and out of the works for treatment.

It was such cases as these that swelled the list, which by October and November was reduced very greatly, and had approached near the vanishing point, so far as tetryl was concerned, when work ceased on November 21st, 1916.