Effects of Some Alkylbenzenesulfonates, Alkyl Sulfates and Alkanesulfonates on Disease Development of Some Plant Viruses*

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(Received December 6, 1979)

Several compounds which belong to the alkylbenzenesulfonates, alkyl sulfates and alkanesulfonates were tested for their antiviral activities. Alkylbenzenesulfonates were more effective against the disease development caused by CMV (cucumber mosaic virus) and CGMMV (cucumber green mottle mosaic virus) than that of TMV (tobacco mosaic virus). Among the test compounds, calcium octylbenzenesulfonate was the most effective on CMV. Calcium decylbenzenesulfonate proved most effective on CGMMV. Among the alkyl sulfates, sodium decyl sulfate was specifically effective on the disease development caused by CGMMV. The antiviral activities of the alkanesulfonates on TMV, CMV and CGMMV were low in general, when compared with those of other groups of the test compounds. Some metal salts of branched dodecylbenzenesulfonate were also examined for their antiviral activities on the three viruses mentioned.

INTRODUCTION

Attempts to control plant virus diseases by chemotherapy have been made since the early part of this century by many plant pathologists; many substances have been reported to be active inhibitors. These include some inhibitors of virus multiplication and protectors against virus infection.

Although discovery of multiplication inhibitors was considered as the real purpose for studying antiviral substances, such substance was successfully developed for practical use. Therefore, several infection protectors, including substances found earlier as well as those found recently, have been studied and attempts again made to develop them.

Preliminary studies showed that some infec-

tion inhibitors such as protein extracted from *Phytolacca americana*, skim milk etc., showed more or less of a surface-active property on plants. Accordingly, the authors have examined some surfactants which are still used as auxiliary agents of many pesticides and detergents, to ascertain their antiviral activities on certain mechanically transmitted virus diseases such as TMV, CMV and CGMMV. As a result, several substances were found to be effective against the disease development of these viruses. Among them, some dodecylbenzenesulfonates showed remarkable inhibitory activities.

As for the inhibitory effect of detergent on plant virus infection, Taniguchi (1976) reported that sodium dodecyl sulfate (SDS) and Triton X were effective in controlling TMV infection on *Nicotiana tabacum* var. Samsun NN and *Phaseolus vulgaris* and to inhibit local lesion formation.¹⁾ Takagi *et al.* (1978) showed that inhibitory activities of nonionic detergent on TMV infection were closely related to their hydrophilic-lipophilic balances.²⁾

* Antiviral Effects of Some Anionic Surfactants on Plants (Part I)

The majority of this study was presented at the Meeting of the Pesticide Science Society of Japan, 1978.

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Takagi *et al.* (1979) also reported that copper bis(ethylenediamine) bis(dodecylbenzenesulfonate) (Sanyol®) and copper hydroxynonylbenzenesulfonate (Yonepon®) were effective in controlling the local lesion formation of TMV on *Phaseolus vulgaris* var. Pinto and TMV disease development on *Nicotiana tabacum* var. *Xanthine*.³⁾

This paper presents results concerning antiviral activities of some detergents and their relationship to chemical structures.

MATERIALS AND METHODS

1. Test Chemicals

Alkylbenzenesulfonates (*P*-isomer in large part) alkyl sulfates and alkanesulfonates as listed in the tables were supplied by Toho Chemical Co. A 10% alcohol aqueous solution of the test chemicals was used in the experiments.

2. Virus Inocula

CMV (cucumber mosaic virus) inoculum was prepared as follows; 1 g of CMV-inoculated and 7 day-incubated cucumber plants crushed by ball mill, and extracted with 100 ml of 1×10^{-2} M phosphate buffer (pH 6.98).

TMV (tobacco mosaic virus) inoculum was prepared from 0.1 g of TMV-diseased tomato plants mixed with 100 ml of distilled water, and CGMMV (cucumber green mottle mosaic virus) inoculum was prepared by extracting 2 g of CGMMV-diseased cucumber plants mixed with 100 ml of distilled water.

3. Test Plants and Pot Tests

Cucumber plants used as hosts of CMV and CGMMV were cultivated in an air-conditioned greenhouse for 2 weeks under 28°C in the daytime and 23°C at night.

Tomato plants used as hosts of TMV were cultivated under the same conditions in the above-mentioned greenhouse for 4 weeks.

French bean (*Phaseolus vulgaris* var. Pinto) used for the local lesion assay of TMV was cultivated in the same greenhouse for 2 weeks.

Pot tests were carried out by airbrush-inoculation technique according to the method described by Huang *et al.*^{4,5)} One % of carborundum was used for the inoculation of TMV and CGMMV; 10% was used for that

of CMV.

Local lesion assay was carried out using cotyledons of French bean (Cultivar: Ohtenashi) for TMV. In this assay, inoculation was carried out using the usual method of rubbing with a cotton ball.

Evaluation of preventive value was made by comparing numbers of infected plants in the drug-treated group and those in the untreated group for pot test.

Each trial utilized 10 seedlings and was replicated more than 3 times.

The local lesion assay was conducted by comparing local lesion formation of a drug-treated leaf and that of an untreated leaf located on the opposite side of the treated leaf.

4. Application of Test Chemicals

The test chemicals were sprayed on the test plants one hr before inoculation for the pot assay using systemic hosts, such as tomato plant for TMV and cucumber plant for CMV or CGMMV.

The test chemicals on the other hand were applied with paint brush on cotyledons of French bean for the local lesion assay of TMV.

RESULTS

1. Effects of Alkylbenzenesulfonates on Disease Development Caused by TMV, CMV, and CGMMV

Alkylbenzenesulfonates, as listed in Table 1, were assayed for their antiviral activities.

Among these compounds, octyl and decyl derivatives showed remarkable effect on the disease development of these viruses. Calcium salts were more effective than sodium salts.

Further, calcium *n*-octyl derivatives was specifically effective on CMV, while calcium decyl derivative was specifically effective on CGMMV. None of them showed a high effectiveness on TMV.

As for the local lesion assay carried out by TMV on French bean, it was shown that octyl, decyl and dodecyl derivatives were remarkably effective against local lesion formation; their efficacy was higher than 90%, as shown in Fig. 1.

Table 1 Effects of *n*-alkylbenzenesulfonates on disease development of TMV, CMV and CGMMV.

Compounds	TMV (%)	CMV (%)	CGMMV (%)
Sodium butylbenzenesulfonate	0	40	31
" hexyl "	23	30	54
" octyl "	74	80	66
" decyl "	36	60	89
Calcium butyl "	0	0	31
" hexyl "	36	40	54
" octyl "	36	100	89
" decyl "	23	60	100
" dodecyl "	38	80	86
Aluminum dodecyl "	58	53	92
Sodium alginate (1%)	28	9	16

All compounds were tested by foliar application with a concentration of 5,000 ppm except sodium alginate.

Fig. 1 Relationship between carbon number in alkyl radical and antiviral activity of *p*-*n*-alkyl benzene sulfonates.

2. Effects of Alkyl Sulfates on Disease Development Caused by TMV, CMV and CGMMV

Alkyl sulfates, as listed in Table 2, were assayed to determine their antiviral activities. Among these, only one compound, sodium *n*-decyl sulfate, was specifically effective on the disease development caused by CMV. Other derivatives, however, were not so effective on the test viruses. The decyl and dodecyl derivatives were rather effective as inhibitors of local lesion formation of TMV on French bean. Sodium salt of the compounds were slightly more effective than calcium

salts, as shown in Fig. 2.

3. Effects of Some Sodium Alkane Sulfonates on Disease Development on TMV, CMV and CGMMV

Several derivatives of sodium alkane sulfonates, as listed in Table 3, were assayed to determine their antiviral activities. Among the derivatives used in this experiment, some showed a little inhibitory effect on the disease development, among which the effect of the dodecyl derivative was the highest.

The antiviral activities of the compounds

Table 2 Effects of *n*-alkyl sulfates on disease development of TMV, CMV and OGMMV.

Compounds		TMV (%)	CMV (%)	CGMMV (%)
Sodium butyl	sulfate	0	0	0
"	hexyl "	0	20	31
"	octyl "	0	0	8
"	decyl "	49	100	54
"	dodecyl "	45	47	69
"	tetradecyl "	0	0	8
"	octadecyl "	19	0	31
"	oleyl "	23	40	0
Calcium butyl	"	0	0	8
"	octyl "	0	20	77
"	decyl "	36	20	77
"	dodecyl "	27	40	62
"	octadecyl "	23	0	31
Sodium alginate (1%)		28	9	16

All compounds were tested by foliar application with a concentration of 5,000 ppm except sodium alginate.

Fig. 2 Relationship between carbon number in alkyl radical and antiviral activity of *n*-alkanesulfonate and *n*-alkyl sulfates.

were not so high in providing an inhibitory effect against local lesion formation of TMV on French bean when compared with those of alkyl sulfates or alkylbenzenesulfonates.

4. Effects of Some Branched Types of Dodecylbenzenesulfonate on TMV, CMV and CGMMV

As shown in Table 4, most of the salts of the dodecylbenzenesulfonates exhibited their inhibitory activities against one or more of

the tested diseases. Copper salt was most effective against TMV on tomato plant, while aluminum salt was most effective against CMV on cucumber plant.

As for inhibition on CGMMV disease development of cucumber plant, most of the salts such as calcium, ammonium, cobalt salts inhibited development more than 80%.

DISCUSSION

As described above, many alkylbenzene-

Table 3 Effects of some sodium *n*-alkanesulfonates on disease development of TMV, CMV and CGMMV.

Compounds	TMV-pot (%)	TMV-L. (%)	CMV-pot (%)	CGMMV-pot (%)
Sodium butanesulfonate	0	0	0	0
" hexane "	0	2	0	0
" octane "	40	22	7	1
" decane "	40	52	47	14
" dodecane "	58	45	47	31
" tetradecane "	62	27	40	43
" octadecane "	23	33	0	31
Sodium alginate (1%)	28	52	9	16

All compounds were tested by foliar application with a concentration of 5,000 ppm except sodium alginate.

TMV-pot means a pot test of TMV disease development and TMV-L. means local lesion assay of TMV.

Table 4 Effects of some dodecylbenzenesulfonates (branched types) on disease development of TMV, CMV and CGMMV.

Compounds	TMV-pot (%)	TMV-L. (%)	CMV-pot (%)	CGMMV-pot (%)
Calcium dodecylbenzenesulfonate	41	78	62	80
Sodium "	29	97	70	71
Ammonium "	23	89	70	85
Cobalt "	40	82	60	85
Magnesium "	58	97	70	16
Aluminum "	40	91	90	69
Copper "	87	92	80	77
Tin "	14	93	70	69
Sodium alginate (1%)	28	52	9	16

All compounds were tested by foliar application with a concentration of 5,000 ppm except sodium alginate.

TMV-pot means a pot test of TMV disease development and TMV-L. means local lesion assay of TMV.

sulfonates, alkyl sulfates and alkanesulfonates demonstrated inhibitory effect against virus infections and their disease development on plants. Among these, alkylbenzene-sulfonates were much more effective than the other groups. However, they were more or less phytotoxic, when a concentration higher than 5,000 ppm was used.

Water soluble sodium salts were rather more phytotoxic than water insoluble calcium salts. Yet, generally speaking, decyl derivatives were more effective than dodecyl derivatives in the groups of alkylbenzenesulfonates and alkylsulfates. However, dodecylbenzenesulfonate, especially its branched type, has been more popularly than other

derivatives.

According to our preliminary tests on antiviral activity, the branched type of dodecylbenzenesulfonates was as effective as the linear one. It is said that the linear type is more easily degraded by some microorganisms in natural environment than the branched one.

Therefore, it may be said that the calcium dodecylbenzenesulfonate, especially its linear type, would be the most promising one for practical use.

ACKNOWLEDGEMENT

The authors express their thanks to Mrs. Y. Kobayashi and Miss A. Tanaka for their skilled techni-

cal assistance.

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要 約

数種アルキルベンゼンスルホン酸塩、アルキル硫酸塩およびアルカンスルホン酸塩の TMV, CMV, CGMMV に対する防除効果

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30 数種の界面活性剤アルキルベンゼンスルホン酸塩、

アルキル硫酸塩、アルカンスルホン酸塩の TMV, CMV, および CGMMV に対する抗ウイルス性を調べた結果、上記 3 グループの物質のうち、アルキルベンゼンスルホン酸塩の活性が高く、TMV に対するよりも CMV, CGMMV に対する活性が高いことが認められた。そのなかでも CMV に対し、オクチルベンゼンスルホン酸カルシウム塩、CGMMV に対し、デシルベンゼンスルホン酸ナトリウム塩の活性が最も高いことが判明した。アルキル硫酸塩についてはデシル硫酸ナトリウムが CGMMV に対して最も高い活性を示した。アルカンスルホン酸ナトリウムは概して他の 2 グループの化合物に比べて活性が低い。分岐型デシルベンゼンスルホン酸塩の数種金属塩について調べたところ、各種塩にはおのおの TMV, CMV, CGMMV に対する特異性に違いが認められた。