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RESEARCH COMMUNICATIONS

Some characteristics of point discharge current during two pre-monsoon season thunderstorms at Pune

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Measurements of point discharge current were made at Pune during two pre-monsoon season thunderstorms of 1987 and 1988. The monthly distribution of the number of days of thunderstorms in the pre-monsoon months of 1987 was seen to vary from that of 1988 though the total number of seasonal thunderstorm days on both occasions were equal. The daywise features of point discharge current on the days of thunderstorm during 1987 and 1988 are presented. Normalized frequency distribution of spells and diurnal time duration of point discharge current and the values of charge received by the earth are also presented.

DURING the periods of thunderstorms when strong electric fields exist, transfer of negative/positive charge to the earth through point discharges from the surface irregularities takes place. Among conduction current, precipitation current, lightning and the point discharge current which contribute to the transfer of charge to the earth, the point discharge current plays a prominant role since its single contribution to the charge transfer is markedly higher than those of the rest[1]. Further, the studies[2-11] made of the ratio of negative to positive charge transferred to the earth by point discharges indicate that it is varying in the range 1.3 to 2.9. These studies indicate that, perhaps, this ratio is greater in tropical and subtropical regions than in the temperate regions. Also, since the total number of daily thunderstorms taking place[12] all over the earth's surface is 44×10^3, the importance of the process of point discharge current in the transfer of charge to earth as well as for the global electric budget becomes much more evident.

It has been reported[13] that the separation between charge centres of a thundercloud due to strong wind shears can extend up to 100 km. Thus the positive charge centre is out on its own ahead of the storm and discharges to ground take place directly. Asuma *et al.*[14] confirmed the earlier views that point discharges at ground level modified ground-level electric field and enhanced the mirror-image effect at the surface more than above. Studies[15] have indicated that thunderstorms often originate in preferred regions of topography and initiation sites tend to cluster into identifiable geographic locations or genesis zones. Imyanitov[16] showed that electrical properties of thunderclouds differ appreciably from those which were supposed earlier and he established the existence of thunder phenomena even in the stratiform clouds.

Several investigators have taken an account of the negative to positive charge ratio and the net balance charge received by 1 km^2 area of the earth by point discharges in thunderstorm situation for subtropical[2-6] and tropical[7-11] regions. Even considering the importance of the subject, we have carried out a study of the observations of point discharge current at Pune (18°32′ N, 73°51′ E, 559 m asl) during pre-monsoon seasons (March–June) of 1987 and 1988. The results are presented here.

The point discharging element consisted of a platinum/10% iridium needle 0.5 mm in diameter and about 2 cm long erected at a height of 14 m above the ground level. Current through the needle was carried by a coaxial cable and fed to an operational amplifier system. The output was given to an 1 mA strip chart recorder run at 1 cm per minute and a continuous record of point discharge current was obtained. The instrument was calibrated in the laboratory. The measurable range of current was 0.05 to ±4.50 μA. The electronic system is described in detail elsewhere[17].

There were 11 and 10 thunderstorms during pre-monsoon seasons (March–June) of 1987 and 1988 respectively. During the activity of thunderstorms, point discharge current occurred quite often. Spells of current used to be both positive/negative. For each such spell of current, duration in minutes and the time in IST were noted.

One minute interval values of point discharge current from the continuous records have been used for analysis. For each spell of either polarity, the mean value of point discharge current per spell was found. The spellwise mean values of either polarities during a day were used to find daily average current of either polarity by the weighted average technique. Tables 1 and 2 give details of dates of thunderstorms, daily total duration (in min, T±), daily average current (± μA), charge flown to the earth (± mC) through point discharge current for pre-monsoon thunderstorm dates for both seasons respectively. Tables 1 and 2 also give seasonal net duration, net average current, monthly and net seasonal charge flown to the earth for both seasons.

Frequencies of durations of spells of current of either polarity were also found by considering individual spell durations in the range 0–10, 11–20, 21–30, ..., >90 min. Total spell duration in each range was expressed as percentage of the net duration for either polarity seasonswise (Table 3). Also, by considering actual timing (IST) of individual spells of either polarity, time occupied during each hour (1300–1400, 1400–1500 h, etc.) was found and expressed as percentage of the seasonal total time for either polarity (Table 4).

It is seen from the Tables 1 and 2 that the monthly distribution of thunderstorm days in April, May and June of 1987 and 1988 was different, being 0/7, 6/1 and 5/2 respectively. As such, these days were compared with the monthly normal[18] thunderstorm days for Poona. This comparison also showed noticeable excess/deficit in the number thunderstorm days during the months of the same season for 1987 and 1988. In view of the above differences it was thought appropriate to give figures of the positive and negative charges received by the earth during these months in addition to the seasonal values which are given in Tables 1 and 2. Analysis of the spell durations and the diurnal time occupied by the point discharge current was also done.

A comparison of the data for seasonal positive charge (Tables 1 and 2) received by the earth in 1987 and 1988 shows that it was +31.51 mC in 1987 and +16.14 mC in 1988. Similarly the seasonal negative charge received was −19.09 mC in 1987 and −21.79 mC in 1988. In the pre-monsoon season of 1987 the thunderstorms were in May and June whereas in 1988 majority of them were in April. The seasonal ratio of negative to positive charge in 1987 was 0.61 and in 1988 it was 1.35.

Analysis of the frequency distribution of spell durations of point discharge current of both polarities

Table 1. Daily statistics of point discharge current of either polarity on the days of thunderstorms during pre-monsoon season of 1987 at Pune.

Date of thunder-storms	Daily total duration of positive pdc (in min, T+)	Daily av. pdc (+μA)	Charge flown to the earth (+mC)	Daily total duration of negative pdc (in min, T−)	Daily av. pdc (−μA)	Charge flown to the earth (−mC)
15.5.'87	58	0.62	2.16	43	0.27	0.70
21.5.'87	16	0.61	0.58	91	1.05	0.57
23.5.'87	42	0.31	0.78	62	0.62	2.31
24.5.'87	306	0.57	10.46	45	0.44	1.19
26.5.'87	130	0.61	4.76	95	0.99	5.64
27.5.'87	85	0.71	0.36	15	0.30	0.27
01.6.'87	44	0.36	0.95	66	0.51	2.02
25.6.'87	74	0.69	3.06	30	0.74	1.33
26.6.'87	50	0.47	1.41	130	0.42	3.28
27.6.'87	43	0.36	0.93	56	0.32	1.07
28.6.'87	190	0.53	6.04	28	0.42	0.71
Total days of thunder-storms	Seasonal net duration in minutes	Net av. current	Charge in May	Seasonal net duration (in min)	Net av. current	Charge in May
11	1038	0.53(0.13)	+19.12	661	0.55(0.26)	−10.68
			Charge in June			Charge in June
			+12.39			− 8.41
		Net seasonal charge	+31.51		Net seasonal charge	−19.09

Ratio of net seasonal negative charge to net seasonal positive charge = 0.61.
Figures in parentheses indicate standard deviation.

Table 2. Daily statistics of point discharge current of either polarity on the days of thunderstorms during pre-monsoon season of 1988 at Pune.

Date of thunder-storms	Daily total duration of positive pdc (in min, T+)	Daily av. pdc (+μA)	Charge flown to to the earth (+mC)	Daily total duration of negative pdc (in min, T−)	Daily av. pdc (−μA)	Charge flown to the earth (−mC)
08.4.'88	123	0.17	1.26	Nil	Nil	Nil
09.4.'88	111	0.33	2.20	133	0.51	4.07
12.4.'88	90	0.13	0.70	12	0.21	0.15
13.4.'88	77	0.58	2.68	137	1.14	9.37
22.4.'88	30	0.22	0.40	Nil	Nil	Nil
24.4.'88	148	0.38	3.37	28	0.59	0.98
27.4.'88	25	0.47	0.70	118	0.44	3.12
03.5.'88	43	0.63	1.63	62	0.38	1.41
07.6.'88	78	0.50	2.34	77	0.30	1.39
12.6.'88	36	0.41	0.86	80	0.27	1.30
Total days of thunder-storms	Seasonal net duration (in min)	Net av. current	Charge in April	Seasonal net duration (in min)	Net av. current	Charge in April
10	761	0.38(0.16)	+11.31	647	0.48(0.28)	−17.69
			Charge in May and June + 4.83			Charge in May and June − 4.10
		Net seasonal charge	+16.14		Net seasonal charge	−21.79

Ratio of net seasonal negative charge to net seasonal positive charge = 1.35.
Figures in parentheses indicate standard deviation.

Table 3. Frequency distribution of spell durations of point discharge current of either polarity for the pre-monsoon thunderstorms at Pune.

	Year	0–10	11–20	21–30	31–40	41–50	51–60	61–70	71–80	81–90	>90
		Class intervals (in min) of the spell durations of PDC — Normalized frequency distribution									
Positive PDC	1987	5	15	7	10	12	12	6	8	8	17
	1988	5	35	11	8	5	15	—	10	11	—
Negative PDC	1987	18	24	12	11	14	8	—	—	—	12
	1988	4	19	4	22	06	17	—	12	—	15

PDC, Point discharge current.

Table 4. Diurnal variation of percentage time occupied by point discharge current of either polarity during pre-monsoon season thunderstorms of 1987 and 1988 at Pune.

	Year	1300 1400	1400 1500	1500 1600	1600 1700	1700 1800	1800 1900	1900 2000	2000 2100	2100 2200	2200 2300	2300 2400	2400 0100	0100 0200	0200 0300	0300 0400	0400 0500	0500 0600	0600 0700
		Diurnal hours — Time occupied (in min) expressed as percentage of the seasonal total time of PDC																	
Positive PDC	1987	6	11	19	22	11	7	11	4	1	1	3	1	—	1	—	—	—	1
	1988	—	1	16	13	17	25	11	6	1	5	2	1	—	—	—	—	—	—
Negative PDC	1987	—	6	12	24	12	11	7	3	2	5	3	6	7	2	—	—	—	1
	1988	—	—	4	1	21	34	15	3	10	5	7	—	—	—	—	—	—	—

PDC, Point discharge current.

is shown in Table 3. In 1987 positive current durations ⩾50 min contributed 50% of the total time for positive current duration whereas in 1988 positive current durations ⩽30 min contributed 50%. Similarly in 1987 negative current durations ⩽40 min contributed for 65% of the total time for negative duration whereas in 1988 negative current durations ⩾40 min contributed for 50% of the total time.

By considering actual timings (IST) of individual spells of either polarity, time occupied during each hour interval (1300–1400, 1400–1500, etc) was found and expressed as percentage of the seasonal total time (Table 4). It is noticed that 72 to 87% of the total duration of point discharge current was limited up to 2000 h during both seasons. However on looking for the activity beyond mid-night hours (2300–2400) we notice that during 1987, 19% of time for negative current and 6% of time for positive current was occupied and the activity lasted untill early morning hours. Such a feature was not noticed during 1988 season. The extreme edge of diurnal activity of point discharge current in 1988 was up to 0000–0100 h.

The above results suggest that thunderstorms in May–June contributed for excess positive charge than negative charge, and thunderstorms in April contributed for excess negative charge. In 1987 longer durations of positive current prevailed than those of negative and in 1988 the reverse was noticed. During 1987 an appreciable duration of point discharge current persisted even beyond mid-night hours unlike in the year 1988. However, since the above results are based on limited observations these inferences should be taken with sufficient reservation and detailed verification is necessary from future works.

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Study of rapid reactions by the steady state principle: kinetics of the reaction between vitamin C and iodine in aqueous solution

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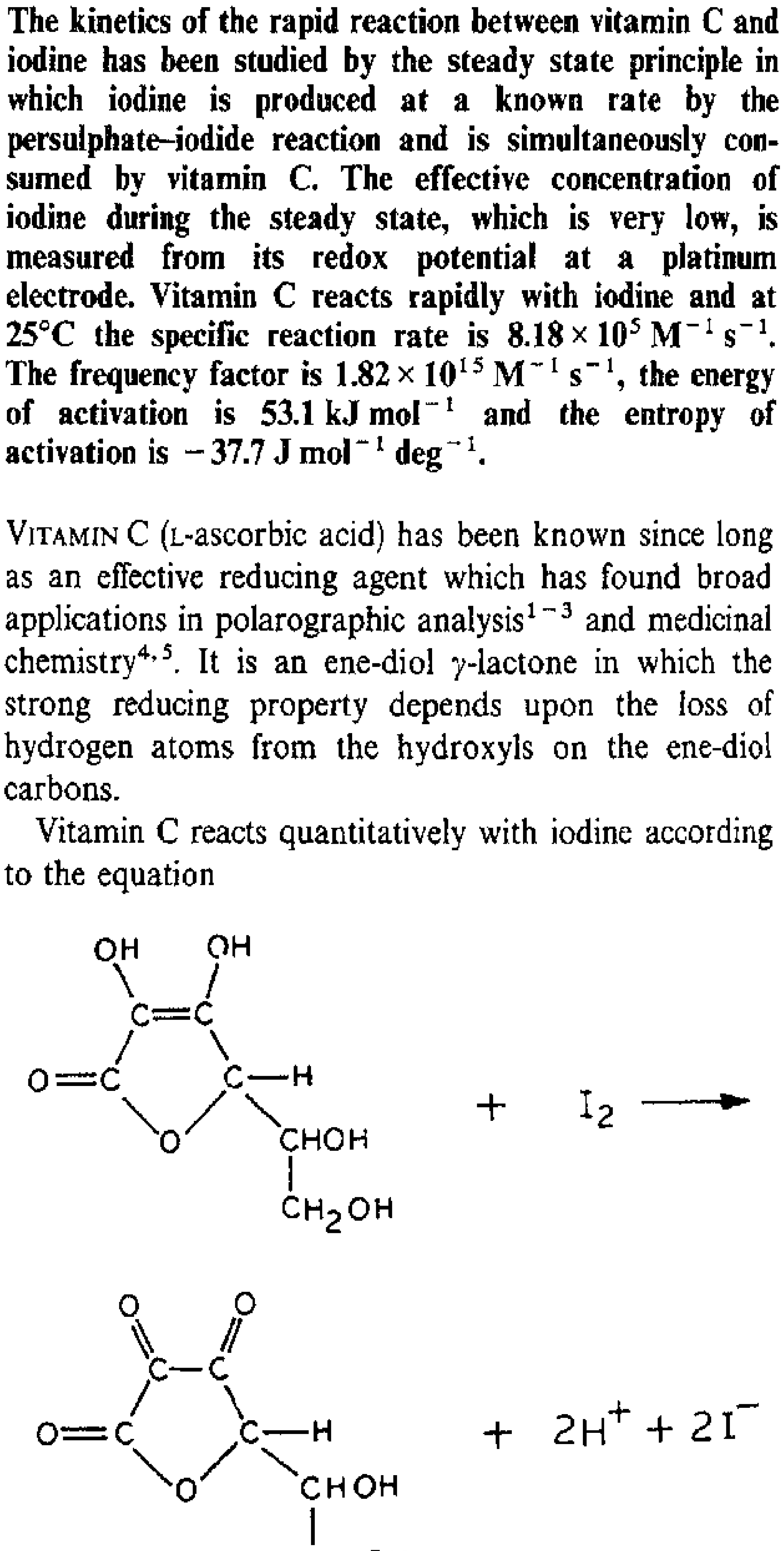
The kinetics of the rapid reaction between vitamin C and iodine has been studied by the steady state principle in which iodine is produced at a known rate by the persulphate–iodide reaction and is simultaneously consumed by vitamin C. The effective concentration of iodine during the steady state, which is very low, is measured from its redox potential at a platinum electrode. Vitamin C reacts rapidly with iodine and at 25°C the specific reaction rate is 8.18×10^5 M^{-1} s^{-1}. The frequency factor is 1.82×10^{15} M^{-1} s^{-1}, the energy of activation is 53.1 kJ mol^{-1} and the entropy of activation is -37.7 J mol^{-1} deg^{-1}.

VITAMIN C (L-ascorbic acid) has been known since long as an effective reducing agent which has found broad applications in polarographic analysis[1–3] and medicinal chemistry[4,5]. It is an ene-diol γ-lactone in which the strong reducing property depends upon the loss of hydrogen atoms from the hydroxyls on the ene-diol carbons.

Vitamin C reacts quantitatively with iodine according to the equation



In this work iodine is present mostly as the tri-iodide ion, I^{-3}, but for simplicity it is represented as I_2.

The reaction occurs rapidly and, surprisingly, the kinetics of the reaction has not been reported in the literature. The usual spectrophotometric technique for the study of rapid reactions is of limited use in the present case because at low concentrations of the reactants needed for such technique, the absorption due to iodine is too low for accurate measurements. Hence