A picosecond electrical signal from chloroplasts related to primary events of photosynthesis.

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When a suspension of chloroplasts is illuminated with non-saturating flashes a photovoltage can be measured with electrodes placed at different positions along the propagation axis of the light (1,2,3,4). At first, this photovoltage was thought to indicate directly a trans-membrane charge separation (1,2), however, later it was ascribed to the different mobilities of positive and negative charge carriers in the plane of the thylakoid membrane (3). Although there is no general agreement on the correct interpretation, the effect is unequivocally related to the photosynthetic charge separation.
In this study we report experiments in which chloroplasts were illuminated with a single 30 ps pulse from a mode-locked ruby laser (λ = 694 nm). The photovoltage was picked up by Ag/AgCl electrodes, amplified by a 3 GHz-amplifier, displayed on a 1 GHz-oscilloscope, and digitized.
Typically photovoltages of about 0.5 mV were measured at flash energies in the order of 100 $\mu J/cm^2$. The photovoltage had a rise time (10 % - 90 %) of 350 ps and a decay time of 1 - 2 ns. The signal was only observed if the photochemical reaction centers were active. It was abolished upon addition of 10^{-5} M dichlorophenyl-dimethylurea (DCMU) under preillumination. After 10 min dark adaptation, which allowed both photosystems to become again reactive, the full amplitude of the photovoltage was restored.
The fast rise time of 350 ps equals the rise time of the slowest electronic component, the oscilloscope. Therefore, the molecular event generating the photovoltage should rise faster than 200 ps. This is compatible with the reported reaction time for the primary donors (P680, P700) to their respective primary acceptors (Pheo a, Chl a). The slower decay time of 1 - 2 ns falls into the expected range for the delocalization of localized dipole fields at the reaction centers by ionic rearrangement alongside the thylakoid membrane.

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